

"AS SEEN ON TV" TOOLS

A BRUTAL PM LAB TEST p.62

Popular Mechanics

Science Technology Automotive Home

Proposed Jupiter Direct Launch Vehicle

A Smarter Rocket?

RENEGADE ENGINEERS SAY THEY HAVE A BETTER PLAN FOR NASA'S COMING MOON MISSIONS. THE BRASS SAYS NO. *INSIDE THE BATTLE OVER THE FUTURE OF SPACEFLIGHT*

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One Tough Animal.

50 NASA and Its Discontents Renegade engineers inside NASA and out claim to have designed a better launch system than the agency's Ares I and V rockets. A frontline report from the battle over the future of manned U.S. spaceflight. **BY DAVID NOLAND**

58 Personal Subs Improved materials and electronics are bringing an age-old dream closer to reality: cruising the depths in your own private submersible. **BY JEFF WISE**

62 If You Act Now ... Hooks that hold 150 pounds! Putty that bonds swiftly to any surface! Fabric that absorbs 20 times its own weight! PM springs for shipping and handling to test the claims of these and 10 other TV products. **BY HARRY SAWYERS**

ON THE COVER

In response to NASA plans to return American astronauts to space, rebel agency engineers helped design this Jupiter 232 launch vehicle, rendered for **POPULAR MECHANICS** by Effekt-Etage.

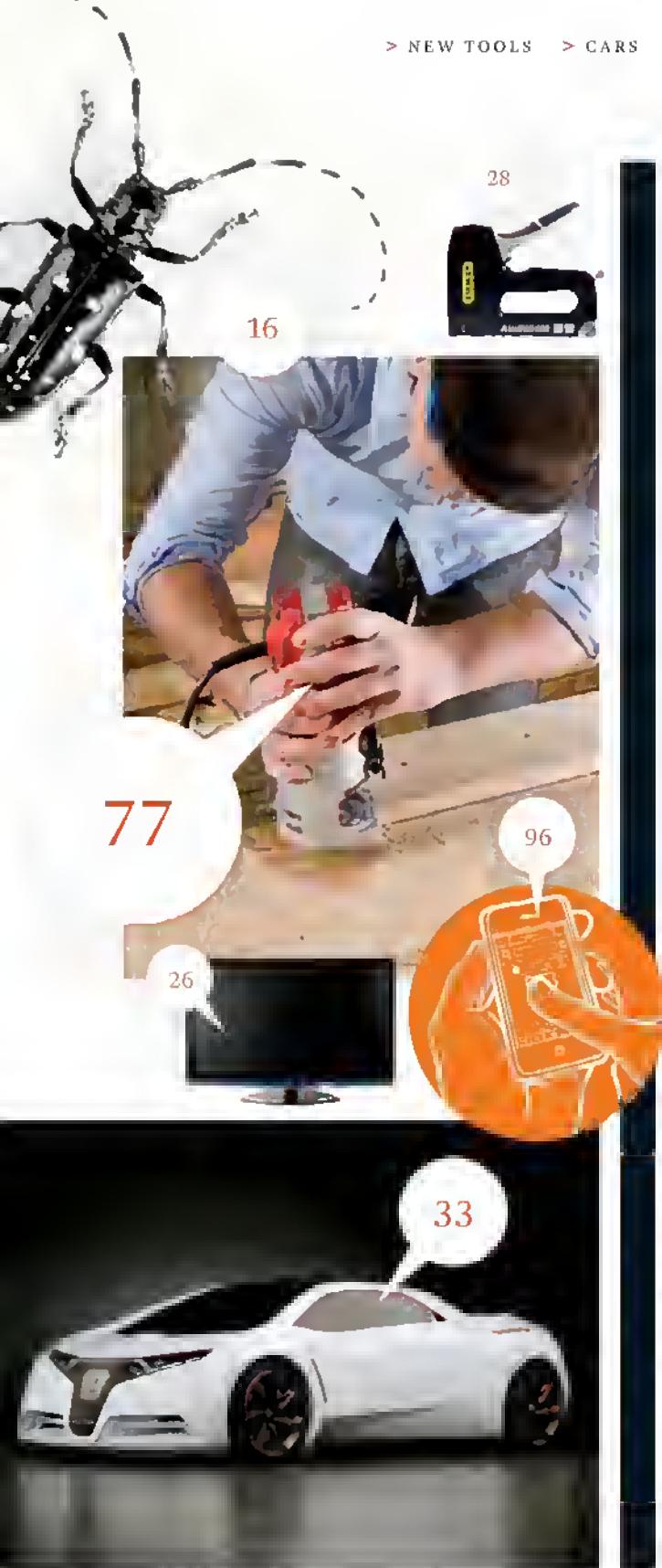
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Mega Vehicles

In a six-month sojourn, PM tracked down America's mightiest moving machines—a front-end loader that scoops 75 tons, a 950-hp firetruck and more. We hitched sky-high rides and took some monsters for a spin.

BY JOHN PEARLEY HUFFMAN





DIY

Home

77 Groove Masters PM puts seven lightweight trim routers through their paces.

80 Replacing a Staircase Handrail A simple upgrade you can do in a day.

84 Homeowners Clinic Avoid the elements with a covered front-door entrance. **Plus:** Saving a leaning shed; setting thermostats on water heaters properly for energy savings and safety.



New Cars

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46 Cows to Kilowatts A Pennsylvania farmer uses the latest tech and some DIY savvy to run his dairy operation on an abundant fuel—manure.

Auto

89 Saturday Mechanic Use our step-by-step guide to figure out why your car won't start.

92 Car Clinic The many benefits of back-probing connections. **Plus:** Diagnosing oil-filter failure; tips to speed defrosting.

Technology

96 Home Control Turning your cellphone into a full-house remote.

98 Digital Clinic Prevent premature gadget battery death. **Plus:** Fixing mislabeled MP3s; how to turn off that annoying Apple startup chime.

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WHAT THEY'RE DOING

THOMAS D. JONES
Space shuttle astronaut
and author of *Sky
Walking*, Tom Jones has
been working with the
Association of Space
Explorers on a plan for
international cooperation
in spotting, and perhaps
deflecting, potentially
deadly asteroids before
they reach Earth. The
United Nations is due to
begin consideration of
the plan this month. Also,
Jones is writing *The Art
of Space*, a book chronicling
the Space Age and
its influence on art.





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RECYCLING

Recycling Debate

I found your story "Is Recycling Worth It?" informative and fitting for the times. However, I've always found it interesting that people don't remember to reduce and reuse, as well. Coca-Cola, for example, began reusing glass soda bottles decades ago. Simply cleaning and refilling the bottles saves on reprocessing the material. Our society needs to become much less throw-away. Recycling should only occur if more efficient options are not available.

ADAM WHITTIER
SUNAPEE, NH

Your recycling article ignores one reality that the author discovered: Recycling often costs more than landfills. Capital is an important resource, and recycling squanders that

ISSUE
12/08

Readers responded to PM's economic and environmental analysis of recycling, missile defense and the DIY Rat Rods movement.

resource—yet the conclusion of the article is that recycling should be encouraged. I find that simply ridiculous.

TIM SLAGLE
DYER, IN

I read your recycling article with great interest. It was very good and quite factual. One aspect that was not covered in detail was the jobs created by recycling, which is of increasing importance in this economic climate. It takes on even more importance when recycling produces raw materials for domestic industries—the resulting goods impact the trade balance, pay taxes and

provide good jobs for American workers.

CLARE MULLETT
WINCHESTER, VA

Shifting the Debate

I was glad to read in your article "Is Recycling Worth It?" that we've ended the debate—and recycling won. Maybe now we can begin the debate on whether the billions of dollars the U.S. invests in missile defense shields, such as those in your article "Standing Guard," are really worth it. I fear an overpopulated future starving itself of resources much more than the possibility of a rogue missile attack.

CHAD INMAN
SAN JOSE, CA

Boneyard Hot Rods

I found your article "Is Gray Primer the New Kandy Apple?" about the retro hot-rod movement fantastic. I've built a highly modified 1967 amphibious car with a Buick V6 mounted midship. Every part for the conversions was out of a boneyard or fabricated, including the shift gate and transfer case. The only item I allowed myself to buy was a digital dash. And a new paint job, of course—rust is a bad idea on a floater. I tip my hat to all who build cars in this manner!

GARY BRIGGS
BINGHAMTON, NY



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08

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Until now, every gallon of gas you bought was ignited by a simple spark plug—an outmoded technology that has barely changed in 100 years. But now you can change to a new eco-friendly pulse plug that uses an advanced technology to make every drop of gas burn better and cleaner.

This new technology—with its eight patents—is based on plasma research supported by the world famous Sandia National Laboratories—and yes, that's *definitely* rocket science.



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2007 Toyota Prius

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TECH WATCH

HOW EI-E DOES ITS HOUSEWORK

1 A mirror mounted above a camera allows the robot to search 240 degrees horizontally and 115 degrees vertically for a laser point.

2 A stereo camera system triangulates the laser-illuminated target's location. It uses an onboard Mac mini and proprietary software.

3 The robot's hand has a camera with a 100-degree horizontal view to locate the object, as well as a pair of six-axis force-torque sensors to monitor physical contact.



Help on Wheels

ROBOTICISTS DESIGN A LASER-GUIDED REPLACEMENT FOR IN-HOME SERVICE DOGS.

BY EMILY MASAMITSU

→ Daily assistance to disabled people at home increasingly has been the domain of skilled dogs and even monkeys. Inspired by these highly trained animals, Georgia Tech's Healthcare Robotics Lab has developed a robot that can perform basic household tasks on command. The EI-E helper bot was first programmed to retrieve objects designated by a human using a laser pointer. Multiple cameras helped guide a grasping, two-fingered hand to the target. After successful early trials, the lab expanded EI-E's interface to combine voice commands with the laser to accomplish more complex tasks, like opening doors. The robot recognizes words such as "tug" or "push" and performs the action on an object illuminated by the laser. But the robot still has some training ahead before it can work outside the lab. "The home environment can be very complex," developer Charles Kemp says. "EI-E still needs to learn what to do when there is a bit of clutter."



KEYED IN TO PARANOIA

+ Computer scientists from UC San Diego have developed a program that can produce duplicates of a key based only on a photograph. They've demonstrated the system using a snapshot of a key taken by a cellphone camera, and have also used a photo of keys sitting on a café table taken with a 5-in. telephoto lens from the roof of a building 195 ft away. The bumps and valleys of a key are coded to numeric sequences that are simple for image-recognition software to unravel. The software hasn't been made public—but watch your keys, anyway.



Desktop Earthquake Detectors

Many laptops have tiny accelerometers that warn a computer that it is being dropped so it can protect its hard drive from impact. Researchers at two California universities realized that these sensors could be used to form a cheap network to detect earthquakes quickly enough to provide useful warnings. Operators of the Quake-Catcher Network (qcn.stanford.edu) are recruiting laptop owners to download software that converts their computers to sensors. Like a screen saver, the software operates only when the computer is idle. The system's largest success occurred last July, when computers detected a magnitude 5.4 quake that caused moderate damage near Los Angeles (above).



Measuring the Great Melt

+ A NASA satellite mission has enabled scientists to "weigh" Alaskan glaciers. The GRACE mission consists of two satellites orbiting about 137 miles apart; the distance between them varies depending on the gravitational pull from the area they're flying over. By calculating the weight change every 10 days, researchers determined that Gulf of Alaska glaciers are losing 84 gigatons of mass each year—equivalent to the volume of the Chesapeake Bay.

PREDICTIVE WEATHER VANES

+ A new sensor that anticipates wind direction could increase the power generated by wind turbines. The system, built by Virginia-based Catch the Wind, shoots a laser to detect the speed and direction of air particles 1000 ft away. The warning gives the turbine time to turn toward the wind or adjust its blade angles to avoid damage from powerful gales. Inventors hope turbines equipped with the system will increase power output by 10 percent.



NEWSBRIEFS

Reports From the Edge of Science
Compiled by Alex Hutchinson

AIR CAR'S SHOT AT STREET CRED

↳ The concept of compressed-air-powered vehicles took a step closer to credibility when Air France and KLM agreed to conduct a six-month trial of the AirPods built by Luxembourg company MDI. The 485-pound, four-seat vehicles will be used to ferry people around airports near Paris and Amsterdam. A U.S. company hopes to release a six-seat version of MDI's cars by 2010.

Superpower Grid

+ Siemens recently unveiled the world's first 800-kilovolt transformer, a key component in an extra-high-voltage line that will carry power between the Chinese provinces of Yunnan and Guangdong. When completed in 2010, the 870-mile transmission line will use 10 of the new 512-ton transformers, each of which is 34 ft tall. Capable of handling 6400 megawatts, the planned transmission link will be the longest in the world and will carry the most juice.

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Enhancing digitized images provides much-needed details of abnormalities found in mammograms. The software highlights subtle differences in density to identify cancerous growths.

NAVAL TECH TARGETS A NEW FOE

CANCER

AN EFFORT TO IDENTIFY UNDERWATER MINES LEADS TO IMPROVED SCREENING FOR BREAST CANCER. BY AMBER FIELDS

→ A method developed for spotting mines in the ocean may provide the unlikely inspiration for a new way to identify breast cancer. It turns out that, just as fish, waves and rocks can interfere with sonar signals, dense breast tissue can hide or distort elements in a mammogram. "The environments may be different, but the goal is the same: to find subtle information," says Michael Duarte, a computer engineer at the

BEETLES FOR BIOFUEL

The future of ethanol fuel might be in the guts of a Chinese beetle.

BY JOE PAPPALARO

A group of scientists at Penn State University has plumbed the stomach of the Asian long-horned beetle for clues to making ethanol from wood. The bug has been ravaging trees in North America since its accidental import from China in the mid-1990s. But instead of seeing a relentless pest, postdoctoral fellow Scott Geib sees a model for separating useful cellulose from wood, a vital first step in creating ethanol. Trees protect themselves from invaders with a natural polymer

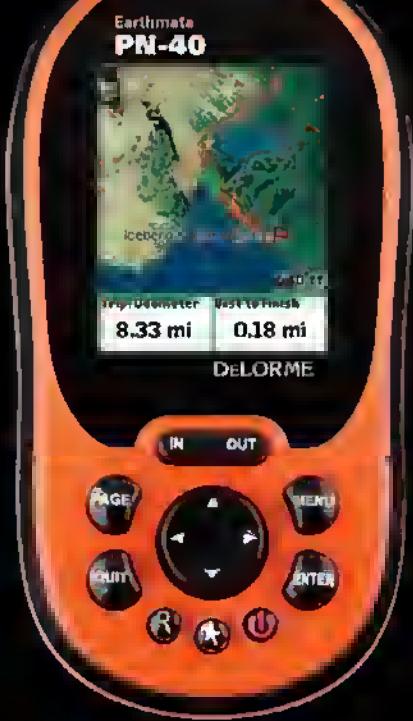
called lignin, which is chemically bonded to the cellulose. Current methods of processing lignin, such as boiling or bathing wood in acid, cost too much, so researchers are keen to find natural alternatives. The larvae of long-horned beetles can eat the hardwood of healthy trees, separating the lignin to process the cellulose and freeing other microorganisms in their bellies to then convert the material into energy. "The stomach of the insect is a microcosm of what we want bioreactors to do," Geib says.

◀ Insect biology could benefit firms like Range Fuels (pilot facility shown), which plans to complete a biomass-to-ethanol plant this year in Georgia.



Naval Undersea Warfare Center and CEO of Advanced Image Enhancement.

Duarte founded AIE to market software, originally developed for the Office of Naval Research, that digitizes an image and then processes the data to highlight specific areas that are suspect. When this software is adapted for use with mammogram machines, it improves the resolution to find density differences in breast tissue, which are caused by cysts, microcalcifications and tumors. This year AIE expects to begin selling breast-imaging software that will create detailed slices of mammogram images. The company also plans to develop algorithms to extract details from many other medical scanners, including chest and orthopedic X-ray machines, ultrasound devices and MRI equipment.



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DELORME



PM INTERVIEW
AUTHOR
AMERICAN RIFLE

Alex Rose

Q You point out that colonial Americans preferred rifles to muskets. How do they differ?

A The primary advantages of a musket are that it loads quickly, hits hard and is very easy to learn how to use. The whole point of 18th-century tactics was to bunch your guts together and send the proverbial hail of lead toward the enemy. But the rifle, from the very beginning, was the tool of specialists. It was made by craftsmen and used by an individual. To use it properly, you had to spend many hours, weeks and months practicing.

Q And frontier warfare favored the more accurate weapon?

A If you were at the top of a mountain, then obviously the rifle's longer range would be great. And if you're in the wilderness, in a place where you can barely see 20 paces and your enemy is flitting between trees, you need to hit and kill with one shot.

Most people think of a rifle only as a firearm with helix grooves in the barrel that help bullets fly straight. But military historian Alex Rose says that Americans have a special relationship with rifles that "represents a way of thinking."

This was an American Indian way of fighting, individual on individual. Another reason for the adoption of the rifle was the need to conserve gunpowder and make more efficient use of lead.

Q Did this emphasis on accuracy survive to the modern era?

A The American army was, shot for shot, the most lethal force on earth from the 1870s onward. U.S. troops, even now, are trained to place their shots more accurately than other countries. Even with the advent of the machine gun, artillery and tanks, the American army retains an emphasis on riflemen being cool and accurate.

Q What happened when U.S. riflemen faced insurgents in Iraqi cities equipped with "spray and pray" AK-47s?

A The AK-47 is legendary, because you can throw it in a mud bath for six months and it won't clog. That's why there's a correlation between AK-47 use and mass conscript armies, toy armies belonging to dictators, child militias in Africa and terrorist outfits. These guys can send out more bullets, but the fact is that U.S. troops work better—in small teams, placing their shots more accurately. I think the insurgents realized this, and they switched to improvised explosive devices so they wouldn't be facing direct U.S. fire.



Modern U.S. infantry use their M4 rifles with a precision that George Washington would recognize.



THE KENTUCKY RIFLE
This first "American rifle" was introduced in the 1720s.

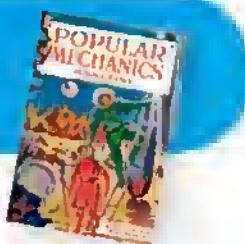
Users of rifles customized shots by tweaking the amount of gunpowder needed for range and accuracy.

American rifles were longer than European guns, maximizing the force of the bolt and improving the weapon's balance.

Stretched barrels of up to 48 in. increased the distance between the front and rear sights for precise targeting.

Smaller caliber bolts reduced the amount of lead in each shot, saving frontiersmen time, money and weight.

Time Machine
MAY 1950



Q In May 1950, almost a decade before the creation of the National Aeronautics and Space Administration, PM reported on engineers who claimed they could start building a lunar spacecraft. "if [only] some agency would finance the project." The government formed NASA in 1958, and within 11 years put American footprints on the moon. Managing a staff of ambitious engineers at work inside a bureaucracy presents almost as many challenges as spaceflight itself, something modern NASA officials are learning (see "NASA and Its Discontents," page 50). The agency is fending off critics from inside and out as it tries to return astronauts to the moon—a reminder that people, not hardware, remain the most vital components of a space program. —Allie Haake

Bipolar Disorder can affect your job, family, and friends.

You can spend years managing the extreme ups and downs, the mood swings and relapses, trying to control your manic symptoms.

Maybe ABILIFY can help

ABILIFY helps control the symptoms of bipolar mania and reduce the risk of manic relapse. It is used for short-term and maintenance treatment of manic or mixed episodes in adults with Bipolar I Disorder.

ABILIFY was shown to have a low risk of significant weight gain in 3-week clinical trials in adults.*

Hundreds of thousands of adults have been prescribed ABILIFY. ABILIFY is one of many treatment options.

Ask your healthcare professional If once-a-day
ABILIFY is right for you.

Individual results may vary.

*Significant weight gain in adults: ABILIFY 2%, sugar pill 3%.

IMPORTANT SAFETY INFORMATION:

Elderly patients with dementia-related psychosis (eg, an inability to perform daily activities due to increased memory loss) taking ABILIFY have an increased risk of death or stroke. ABILIFY is not approved for treating these patients.

Some medicines can increase suicidal thoughts and behaviors in children, teens, and young adults. Serious mental illnesses are themselves associated with an increase in the risk of suicide. When taking ABILIFY call your doctor right away if you have new or worsening mood symptoms, unusual changes in behavior, or thoughts of suicide. Patients and their caregivers should be especially observant within the first few months of treatment or after a change in dose.

- Alert your doctor if you develop very high fever, rigid muscles, shaking, confusion, sweating, or increased heart rate and blood pressure, as these may be signs of a rare but potentially fatal condition called neuroleptic malignant syndrome (NMS)
- If you develop abnormal or uncontrollable facial movements, notify your doctor, as these may be signs of tardive dyskinesia (TD), which could become permanent
- If you have diabetes or have risk factors or symptoms of diabetes, your blood sugar should be monitored. High blood sugar has been reported with ABILIFY and medicines like it. In some cases, extreme high blood sugar can lead to coma or death
- Other risks may include lightheadedness upon standing, seizures, trouble swallowing, or impairment in judgment or motor skills. Until you know how ABILIFY affects you, you should not drive or operate machinery

The common side effects in adults in clinical trials (>10%) include nausea, vomiting, constipation, headache, dizziness, an inner sense of restlessness or need to move (akathisia), anxiety and insomnia. Tell your doctor about all the medicines you're taking, since there are some risks for drug interactions. You should avoid alcohol while taking ABILIFY.

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.fda.gov/medwatch, or call 1-800-FDA-1088.

Please read the Important Product Information about ABILIFY on the adjacent page.

If you or someone you know needs help paying for medicine,
call 1-888-4PPA-NOW (1-888-477-2669). Or go to www.parc.org





IMPORTANT INFORMATION ABOUT ABILIFY

This summary of the Package Insert contains risk and safety information for patients about ABILIFY. This summary does not include all information about ABILIFY and does not take the place of discussions with your healthcare professional about your treatment. Please read this important information before you start taking ABILIFY and discuss any questions about ABILIFY with your healthcare professional.

Name

ABILIFY® (o-BIL-i-fi) (aripiprazole) (ahr-i-PIP-rah-zole)

What is ABILIFY?

ABILIFY (aripiprazole) is a prescription medicine used for treatment of adult patients with manic or mixed episodes associated with Bipolar I Disorder.

What is Bipolar I Disorder?

Bipolar I Disorder is an illness with symptoms thought to be caused by an imbalance of brain chemicals. People who have Bipolar I Disorder tend to experience extreme mood swings, along with other specific symptoms and behaviors. These mood swings, or "episodes," can take three forms: manic, depressive, or mixed episodes. Common symptoms of a manic episode are: feeling extremely happy, being very irritable and anxious, talking too fast and too much, and having more energy and needing less sleep than usual. Common symptoms of a depressive episode include: feelings of overwhelming sadness or emptiness, low energy, a loss of interest in things, trouble concentrating, changes in sleep or appetite, and thoughts of dying or suicide. A mixed episode includes symptoms that are both manic and depressive.

Who should NOT take ABILIFY?

People who are allergic to ABILIFY or to any substance that is in it. Allergic reactions have ranged from rash, hives and itching to difficulty breathing and swelling of the face, lips, or tongue. Please talk with your healthcare professional.

What is the most important information that I should know about ABILIFY?

Elderly patients, diagnosed with psychosis as a result of dementia (for example, an inability to perform daily activities as a result of increased memory loss), and who are treated with antipsychotic medicines including ABILIFY, are at an increased risk of death when compared to patients who are treated with a placebo (sugar pill). ABILIFY is not approved for the treatment of patients with dementia-related psychosis.

Some medicines can increase suicidal thoughts and behaviors in children, teens, and young adults. Serious mental illnesses are themselves associated with an increase in the risk of suicide. When taking ABILIFY call your doctor right away if you have new or worsening mood symptoms, unusual changes in behavior, or thoughts of suicide. Patients and their caregivers should be especially observant within the first few months of treatment or after a change in dose.

Serious side effects can occur with any antipsychotic medicine, including ABILIFY. Tell your healthcare professional right away if you have any conditions or side effects, including the following:

Stroke or ministroke in elderly patients with dementia: An increased risk of stroke and ministroke has been reported in clinical studies of elderly patients with dementia (for example, increased memory loss and inability to perform daily activities). ABILIFY is not approved for treating patients with dementia.

Neuroleptic malignant syndrome (NMS): Very high fever, rigid muscles, shaking, confusion, sweating, or increased heart rate and blood pressure may be signs of NMS, a rare but serious side effect that could be fatal.

Tardive dyskinesia (TD): Abnormal or uncontrollable movements of face, tongue, or other parts of body may be signs of a serious condition known as TD, which may be permanent.

High blood sugar and diabetes: Patients with diabetes and those having risk factors for diabetes (for example, obesity, family history of diabetes), as well as those with symptoms such as unexpected increases in thirst, urination, or hunger should have their blood sugar levels checked before and during treatment. Increases in blood sugar levels (hyperglycemia), in some cases serious and associated with coma or death, have been reported in patients taking ABILIFY, and medicines like it.

Orthostatic hypotension: Lightheadedness or faintness caused by a sudden change in heart rate and blood pressure when rising too quickly from a sitting or lying position (orthostatic hypotension) has been reported with ABILIFY.

Suicidal thoughts: If you have suicidal thoughts, you should tell your healthcare professional right away.

Dysphagia: Medicines like ABILIFY have been associated with swallowing problems (dysphagia). If you had or have swallowing problems, you should tell your healthcare professional.

What should I talk to my healthcare provider about?

Patients and their families or caregivers should watch for new or worsening mood symptoms, unusual changes in behavior and thoughts of suicide, as well as for anxiety,

agitation, panic attacks, difficulty sleeping, irritability, hostility, aggressiveness, impulsivity, restlessness, or extreme hyperactivity. Call your healthcare provider right away if you have thoughts of suicide or if any of these symptoms are severe or occur suddenly. Be especially observant within the first few months of antidepressant treatment or whenever there is a change in dose.

Tell your healthcare provider:

- About any medical conditions you may have
- Whether you're taking any other prescription or nonprescription (over-the-counter) medicines
- Whether you're pregnant, plan to become pregnant, or are breast-feeding
- If you or anyone in your family has had seizures
- If you or anyone in your family has had high blood sugar or diabetes

What should I avoid when taking ABILIFY (aripiprazole)?

- Avoid overheating and dehydration
- Avoid driving or operating hazardous machinery until you know how ABILIFY affects you
- Avoid drinking alcohol
- Avoid breast-feeding an infant

What are the possible side effects of ABILIFY?

Common side effects in adults include: nausea, vomiting, constipation, headache, dizziness, an inner sense of restlessness or need to move (akathisia), anxiety and insomnia.

It is important to contact your healthcare professional if you experience prolonged, abnormal muscle spasm or contraction which may be signs of a condition called dystonia.

What percentage of people stopped taking ABILIFY due to side effects?

In clinical trials, the percentage of adults who discontinued taking ABILIFY due to side effects was ABILIFY (11%) and for patients treated with sugar pill (9%).

Can I safely take ABILIFY while I'm taking other medications?

ABILIFY can be taken with most drugs; however, taking ABILIFY with some medicines may require your healthcare professional to adjust the dosage of ABILIFY.

Some medicines* include:

- ketoconazole (NIZORAL®)
- quinidine (QUINIDEX®)
- fluoxetine (PROZAC®)
- paroxetine (PAXIL®)
- carbamazepine (TEGRETOL®)

It is important to tell your healthcare professional about all the medicines you're taking, just to be sure.

General advice about ABILIFY:

- ABILIFY is usually taken once a day, with or without food
- ABILIFY should be kept out of the reach of children and pets
- Store ABILIFY Tablets and the Oral Solution at room temperature
- For patients who must limit their sugar intake, be aware that ABILIFY Oral Solution contains sugar
- For patients who cannot metabolize phenylalanine (those with phenylketonuria or PKU), ABILIFY DISCMELT® contains phenylalanine
- If you have additional questions, talk to your healthcare professional

Find out more about ABILIFY:

Additional information can be found at www.abilify.com/bipolardisorder

*NIZORAL is a registered trademark of Janssen Pharmaceuticals, QUINIDEX is a registered trademark of Wyeth Pharmaceuticals; PROZAC is a registered trademark of Eli Lilly and Company, PAXIL is a registered trademark of GlaxoSmithKline; TEGRETOL is a registered trademark of Novartis Pharmaceuticals. Based on Full Prescribing Information as of 05/08 1239550A2.

 Bristol-Myers Squibb  Otsuka America Pharmaceutical, Inc.

Tablets manufactured by Otsuka Pharmaceutical Co., Ltd., Tokyo, 101-8535 Japan or Bristol-Myers Squibb Company, Princeton, NJ 08543 USA.

Orally Disintegrating Tablets, Oral Solution, and Injection manufactured by

Bristol-Myers Squibb Company, Princeton, NJ 08543 USA.

Distributed and marketed by Otsuka America Pharmaceutical, Inc., Rockville, MD 20850 USA.

Marketed by Bristol-Myers Squibb Company, Princeton, NJ 08543 USA.

U.S. Patent Nos. 5,006,528; 6,977,257; and 7,115,587.

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570US08C8S01902 0308L-1112 Printed in USA D8-000010-05-08-ABD May 2008



ROCK STARS

Geologic research may hold the key to large-scale carbon-dioxide control.

BY JON LUOMA

A new study raises hopes that huge volumes of a key greenhouse gas could be converted into inert rock and stored that way essentially forever. Columbia University geologist Peter Kelemen has found that peridotite, a highly reactive rock that covers about 2400 square miles of Oman, naturally reacts with carbon dioxide (CO_2), removing it from the air to form limestone and other carbonates. In a recent study, Kelemen and Columbia geochemist Jürg Matter suggest the natural process could be accelerated a millionfold. The researchers say that CO_2 captured from power plants and other sources could be pumped down boreholes hundreds of feet deep, where the CO_2 would seep into peridotite that has been shattered to expose more surface area. Heat would be added initially to accelerate chemical reactions. But as new carbonate rock began forming, the process could begin feeding on itself, with the heat from the reaction supplementing the Earth's own heat. Kelemen says, "It's a little like setting a coal seam on fire."

• Scientists say that Oman's peridotite could sequester 4 billion tons of CO_2 per year.



NEW FACES OF MICROSATS
THE U.S. AIR FORCE IS PURSUING OTHER RADICAL SATELLITE DESIGNS.

Information Surge

THE PENTAGON NEEDS QUICK WAYS TO GET SMALL SATELLITES INTO SPACE TO FILL A SHORTFALL IN BATTLEFIELD COMMUNICATION. BY ROXANA TIROU

→ Military satellites were once considered to be reliably out of harm's way. But antisatellite weapons and solar flares threaten to transform these important pieces of communications hardware into space junk. Even if nothing goes wrong, tech-reliant U.S. forces can easily outstrip the available local bandwidth when they deploy. To fill the gap, the Air Force's Operationally Responsive Space program is developing smarter microsatellites that can be placed in orbit in less than a year and for under \$20 million. If successful, the program could help provide reliable radio connections and

reconnaissance imagery to troops on the move. The Air Force is sending platforms called TacSats into space, each one field-testing a new capability. One early experimental craft called TacSat-2, launched in late 2007, was equipped with a wide-band sensor that gathered radar and radio signals from the ground, and an imager to identify the signals' sources. TacSat-3, scheduled for liftoff this year, will beam images to troops within 10 minutes of collection. In September, a fourth satellite is scheduled to rise from Alaska; it will have the ability to keep fast-moving ground units permanently linked with commanders and to provide real-time locations of friendly troops. This series of experimental satellites is paving the way for a working prototype, ORS-1, that the Air Force plans to launch in 2010.

Orbital experiments like TacSat-2 (above) may help preserve the U.S. military's space dominance.

CUSat
+ If small satellites could inspect their brethren in orbit, the information could be used to prepare replacements. A concept hatched by the Air Force and Cornell University would launch two tiny satellites; one would take pictures of the other. Officials expect a launch late this year.

Transformational Satellite System (TSAT)
+ The TSAT program is researching orbit-to-ground laser communications. Late last year the Pentagon postponed a contract decision until 2010. This is bad news for Pentagon modernization programs, particularly the Army's Future Combat Systems program, that rely on ever-present satellite communications.

You don't have to be
made of money



\$5,020

So-called "sale" price

Price includes bed, bench, armoire and side table.
Prices subject to change.

to make it look
like you are.



\$2,981

DirectBuy member price

How can you afford not to?

Save up to 50% on nearly everything. Every day.

Designing, renovating or upgrading your bedroom? DirectBuy can save you up to 50% on nearly everything for your home. Kitchens, bathrooms, living and bedrooms, cabinets, flooring, appliances and more. If you make frequent home furnishing purchases or you're planning a serious renovation, the savings can be staggering – far exceeding the cost of membership. Hundreds of top brands. Thousands of products. No hidden markups. Huge savings every day.

Join DirectBuy. How can you afford not to?

members only discounts
DirectBuy

Get your **FREE** Visitor's pass.
Come to our Open House.
1-800-596-6885

shopatdirectbuy.com



UPGRADE



• Cyclonic Power
The bagless cyclonic filter uses three dust fighting layers; two of the components are dishwasher-safe.

• Flipping Brush
No more lost accessories: An always-attached brush head swings into place over the nozzle.

Battery Swap
The removable 18-volt lithium-ion battery can be swapped into other cordless vacuums in Hoover's Platinum line.

Marathon Maid

While plenty of hand vacuums dispense with bags by using cyclonic filtration systems, they can typically handle only small jobs. The reason: Their batteries rarely last longer than 5 minutes a charge. The Hoover Platinum Collection Cordless Hand Vacuum (\$130, hoover.com) purports to last twice as long. In our tests, it did even better, sucking up dirt for more than 13 minutes. — SETH PORGES

Test Drive

SLEEK AUDIO WIRELESS HEADPHONES

We're skeptical of wireless headphones—whatever they add in convenience is usually offset by a loss of sound quality. But in our tests, the **Sleek Audio SA6 W-1 Wireless In-Ear Earphones** (\$300) provided clear sound and full bass, even a whopping 61 ft from the transmitter. The secret: a Wi-Fi-like wireless technology that provides higher fidelity than Bluetooth. Yes, they're pricey, but hey, freedom (including from your headphone jack) is never free. sleek-audio.com

A music-player-docked wireless transmitter (1) broadcasts to a wireless receiver (2), which plugs directly into the headphones (3).



The Test

With the headphones on one side of an old stone fireplace and the receiver on the other, the signal was stopped dead in its tracks.

The 30-ft range inside a typical house with walls and furniture allowed us to move between rooms.

Outdoors, with no obstructions, the headphones worked a full 61 ft away from the receiver.



The swappable attachments on multipurpose oscillating tools make them useful for sanding, cutting, scraping and grinding. But the tools are typically tethered to cords and rely on a limited number of hard-to-find heads. The cordless 12-volt **Bosch PS50 Multi-X** (\$200 to \$230) has lots of new attachments and is backwards-compatible with competitors' older ones. boschtools.com

Robo Dishwasher

Most dishwashers are blind to their surroundings. The **Miele G 2002 La Perla Series Dishwasher** (\$1200 to \$2600) adjusts water heat and drying time based on the kitchen's temperature. At the end of the cycle, the door opens to let in air and speed up drying. The result of these bells and whistles: a faster cycle (the manufacturer claims it's 10 to 15 percent speedier than its peers) and lower energy consumption. miele.com





While cheap, ultraportable netbooks have become popular over the past year, most models' tiny drives and pitiful processors restrict them to simple tasks such as e-mail and word processing. The **HP Mini 1000** (**Starting at \$400**) is one of a new, better crop of machines—it uses Intel's Atom processor, runs Windows XP, and has a 60 GB hard drive and built-in 3G for high-speed Internet access. hp.com

Backyard Backhoe

The backhoe is an ideal tool for digging drainage ditches and clearing large rocks. But unless you run a construction company, owning such an immense piece of equipment is impractical. The garage-friendly **DR Towable Backhoe** (**\$6000**) cuts the machine down to its core (unlike full-size backhoes, there's no front-loader) and can be pulled by a riding mower or ATV. drbackhoe.com



Some new gear is so obviously superior it's impossible to resist. The **CamelBak RaceBak** (**\$100**) is not like that. Frankly, it's weird-looking—a hydration pack without the pack. Its 72-ounce bladder is built into a base-layer shirt. We found it lightweight, aerodynamic and stable—though not our first choice for daily workouts. camelbak.com

First Look

CONSUMER ELECTRONICS SHOW

Beer-lovers have Oktoberfest, cinephiles have Cannes and gadget fiends have the Consumer Electronics Show, which takes over Las Vegas every January. In past years, companies have used the behemoth expo to debut products such as the first HDTV and the first DVR. And while the economy has turned much of this year's CES into a bargain showcase, whiz-bang showstoppers are still on display. Here's a first look at some of this year's highlights. —SETH PORGES

LENOVO THINKPAD USB PORTABLE SECURE HARD DRIVE (\$180)
A modem update to Occam's razor: Sometimes, the simplest digital security is also the best. This external hard drive eschews biometrics for a simple combination lock—users must dial the correct code to access the sensitive data within. lenovo.com



GARMIN APPROACH G5 GOLF GPS (\$500)
GPS chips are now so cheap and flexible that manufacturers can use them in truly niche products. Like this waterproof golf GPS, which comes preloaded with maps of thousands of courses. Even if you don't get lost on the links, it shows the distance to any course target and is likely to impress your tee partners (and isn't that what golf is about?). garmin.com



WOWWEE SPYBALL (PRICE NOT SET)
There are plenty of Internet-enabled surveillance cameras, but none have ever been quite this fun. This rolling, robotic Big Brother can be accessed and controlled using a Web-enabled PC or phone. wowwee.com



CASIO EX-FS10 DIGITAL CAMERA (\$350)

Last year, Casio wowed CES with a digital camera that could shoot at 60 frames per second (most cameras top out at two or three). But the camera was as big as an SLR and cost \$1000. This year, the company has brought high-speed shooting into a smaller, cheaper model—this compact cam can shoot 30 9-megapixel shots in a second and record video at up to 1000 frames per second. casio.com

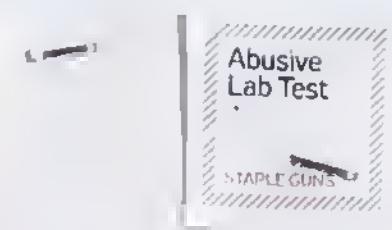
SHARP AQUOS BD SERIES HDTV (PRICE NOT SET)
Ubiquity is a digital format's best friend. That's why the DVD persists, even as superior technology vies to take its place—DVD players are everywhere. If Blu-ray is to succeed over the long term, it needs to find ways to do the same. These 1080p LCD HDTVs are a good start—they are the first to feature a built-in Blu-ray player. sharp.com

SONY HDR-XR520V 240 GB HANDYCAM CAMCORDER (\$1500)
Geotagging has long allowed photographers to match up a picture with a location. This high definition camcorder uses a GPS chip to do the same for videos (it works by embedding the data in a screenshot thumbnail). And in case you get lost, the camcorder's screen turns it into an ad hoc navigator (its hard drive comes loaded with maps of the entire country). sonystyle.com

OPTOMA PICO PROJECTOR (\$300)

Microprojectors were omnipresent at last year's show, but nothing beyond the concept stage was on display. Commercially available pocket-size projectors are finally here. This battery-powered display is one of the first: It plugs into an iPod, cellphone or laptop for on-the-fly viewing. optoma.com





ARROW T50PBN
(\$30) arrowfastener.com



BOSTITCH T6
(\$25) bostitch.com



STANLEY CT10
(\$25) stanleyworks.com

Construction staplers add a little oomph to your standard Swingline, firing off fasteners for tasks like securing wires, screens or fabric to lumber. We pit three staple guns against each other—a classic steel Arrow and two newer models that promise such improvements as intuitive loading and simpler, lighter design. One model did edge out its rivals—but all three tools stood up to our brutal abuse, making for satisfying, jam-free stapling. —HARRY SAWYERS

Depth Test →

We shot staples into low-density poplar (26.7 pounds/cu ft), black cherry (33.3) and white oak (44.3).

• Arrow T50

The job site classic easily sank $\frac{1}{2}$ -in. staples into poplar and handled cherry when we leaned into it. Oak, however, left the staples shaped like the letter M.

• Bostitch T6 **winner!**

This gun breezed through the poplar and was the only one to drive staples flush into cherry. But it didn't fully penetrate the oak.

• Stanley CT10

A skinny base wobbled side to side, driving flush only in poplar. A depth-adjustment feature controls shot force.



Range Test

We measured how far and accurately airborne staples traveled—not a key measure, we admit, but handy for chasing off trespassers.

• Arrow T50

The shortest shooter—staples flew straight for an average of 25 ft.

• Bostitch T6

Although the Bostitch shot 33 ft, aiming was tough; the shots veered left.

• Stanley CT10 **winner!**

The Stanley nailed our target dartboard at a distance of 34 ft.

Jam and Load Test

We loaded and fired dozens of staples on top of one another for a staple pileup that usually leads to Jam City.

• Arrow T50

Clunky reloading of $\frac{3}{8}$ -in. wide staples slowed the Arrow, but staples stacked jam-free; each of 76 rounds sank into the poplar.

• Bostitch T6

This gun reloaded $\frac{1}{4}$ -in.-wide staples, 83 of them, as easily as an office stapler, and it never jammed.

• Stanley CT10 **winner!**

Easy to reload with 84 rounds and billed to fire 20,000 staples sans jam. (We tried a few hundred.) Narrow $\frac{1}{8}$ -in.-wide staples limit you to smaller jobs.

BOTTOM LINE

All three worked in softwoods and survived falls off an 8-ft ladder. The Arrow has classic style, but easy loading, power and light weight nudge the Bostitch past it. Limited by slim staples, the Stanley still works for a wire-running DIYer.



ON THE WEB > For more staple-gun reviews, go to popularmechanics.com/staplegun.



I have poor leg circulation.

And I have a good reason to try to reduce the risk of heart attack or stroke that comes with it.

Plavix can help

Peripheral Artery Disease (P.A.D.) is often described as poor leg circulation, which puts you at double the risk of heart attack or stroke. That's because, if you have poor blood circulation in your legs, you may also have it in your heart and brain. You may feel nothing, but the most common symptom of P.A.D. is pain or heaviness in the legs.

Take the next step. So if you're diagnosed with P.A.D., ask your doctor about a treatment clinically

To learn more, talk to your doctor today or visit www.plavix.com/PAD or call 1-800-344-8857.

IMPORTANT INFORMATION: If you have a stomach ulcer or other condition that causes bleeding, you should not use PLAVIX. When taking PLAVIX alone or with some other medicines including aspirin, the risk of bleeding may increase so tell your doctor before planning surgery. And, always talk to your doctor before taking aspirin or other medicines with PLAVIX, especially if you've had a stroke. If you develop fever, unexplained weakness or confusion, tell your doctor promptly as these may be signs of a rare but potentially life-threatening condition called TTP, which has been reported rarely, sometimes in less than 2 weeks after starting therapy. Other rare but serious side effects may occur.

Please see important product information on following page.

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.fda.gov/medwatch, or call 1-800-FDA-1088.

WITHOUT PLAVIX



WITH PLAVIX



proven to help reduce your risk of heart attack and stroke

associated with P.A.D. PLAVIX helps keep blood platelets from sticking together and forming dangerous clots, the cause of most heart attacks and strokes. Ask your doctor about PLAVIX.

Plavix
(clopidogrel bisulfate) 75 mg tablets

Help reduce your risk of heart attack or stroke.



If you need help paying for prescription medicines, you may be eligible for assistance. Call 1-888-4PPA-NOW (1-888-477-2667), or go to www.ppanc.org.

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sanofi aventis



Bristol-Myers Squibb

US.CLO.08.10.081/November 2008
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264US08AB36B01-11-08



WHO IS PLAVIX FOR?

PLAVIX is a prescription-only medicine that helps keep blood platelets from sticking together and forming clots.

PLAVIX is for patients who have:

- had a recent heart attack.
- had a recent stroke.
- poor circulation in their legs (Peripheral Artery Disease).

PLAVIX in combination with aspirin is for patients hospitalized with:

- heart-related chest pain (unstable angina).
- heart attack.

Doctors may refer to these conditions as ACS (Acute Coronary Syndrome).

Clots can become dangerous when they form inside your arteries. These clots form when blood platelets stick together, forming a blockage within your arteries, restricting blood flow to your heart or brain, causing a heart attack or stroke.

WHO SHOULD NOT TAKE PLAVIX?

You should NOT take PLAVIX if you:

- are allergic to clopidogrel (the active ingredient in PLAVIX).
- have a stomach ulcer
- have another condition that causes bleeding
- are pregnant or may become pregnant.
- are breast feeding.

WHAT SHOULD I TELL MY DOCTOR BEFORE TAKING PLAVIX?

Before taking PLAVIX, tell your doctor if you're pregnant or are breast feeding or have any of the following:

- gastrointestinal ulcer
- stomach ulcer(s)
- liver problems
- kidney problems
- a history of bleeding conditions

WHAT IMPORTANT INFORMATION SHOULD I KNOW ABOUT PLAVIX?

TTP: A very serious blood condition called TTP (Thrombotic Thrombocytopenic Purpura) has been rarely reported in people taking PLAVIX. TTP is a potentially life-threatening condition that involves low blood platelet and red blood cell levels, and requires urgent referral to a specialist for prompt treatment once a diagnosis is suspected. Warning signs of TTP may include fever, unexplained confusion or weakness (due to a low blood count, what doctors call anemia). To make an accurate diagnosis, your doctor will need to order blood tests. TTP has been reported rarely, sometimes in less than 2 weeks after starting therapy.

Gastrointestinal Bleeding: There is a potential risk of gastrointestinal (stomach and intestine) bleeding when taking PLAVIX. PLAVIX should be used with caution in patients who have lesions that may bleed (such as ulcers), along with patients who take drugs that cause such lesions.

Bleeding: You may bleed more easily and it may take you longer than usual to stop bleeding when you take PLAVIX alone or in combination with aspirin. Report any unusual bleeding to your doctor.

Geriatrics: When taking aspirin with PLAVIX the risk of serious bleeding increases with age in patients 65 and over.

Stroke Patients: If you have had a recent TIA (also known as a mini-stroke) or stroke taking aspirin with PLAVIX has not been shown to be more effective than taking PLAVIX alone, but taking aspirin with PLAVIX has been shown to increase the risk of bleeding compared to taking PLAVIX alone.

Surgery: Inform doctors and dentists well in advance of any surgery that you are taking PLAVIX so they can help you decide whether or not to discontinue your PLAVIX treatment prior to surgery.

WHAT SHOULD I KNOW ABOUT TAKING OTHER MEDICINES WITH PLAVIX?

You should only take aspirin with PLAVIX when directed to do so by your doctor. Certain other medicines should not be taken with PLAVIX. Be sure to tell your doctor about all of your current medications, especially if you are taking the following:

- aspirin
- nonsteroidal anti-inflammatory drugs (NSAIDs)
- warfarin
- heparin

Be sure to tell your doctor if you are taking PLAVIX before starting any new medication.

WHAT ARE THE COMMON SIDE EFFECTS OF PLAVIX?

The most common side effects of PLAVIX include gastrointestinal events (bleeding, abdominal pain, indigestion, diarrhea, and nausea) and rash. This is not a complete list of side effects associated with PLAVIX. Ask your doctor or pharmacist for a complete list.

HOW SHOULD I TAKE PLAVIX?

Only take PLAVIX exactly as prescribed by your doctor. Do not change your dose or stop taking PLAVIX without talking to your doctor first.

PLAVIX should be taken around the same time every day, and it can be taken with or without food. If you miss a day, do not double up on your medication. Just continue your usual dose. If you have any questions about taking your medications, please consult your doctor.

OVERDOSE

As with any prescription medicine, it is possible to overdose on PLAVIX. If you think you may have overdosed, immediately call your doctor or Poison Control Center, or go to the nearest emergency room.

FOR MORE INFORMATION

For more information on PLAVIX, call 1-800-633-1610 or visit www.PLAVIX.com. Neither of these resources, nor the information contained here, can take the place of talking to your doctor. Only your doctor knows the specifics of your condition and how PLAVIX fits into your overall therapy. It is therefore important to maintain an ongoing dialogue with your doctor concerning your condition and your treatment.

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Despite tough economic times, Stauer has had a very good year. It's time for us to give back. That's why we're offering this stunning, 18" strand of genuine cultured white pearls for **FREE** (you only pay the basic shipping and processing). This is a classically beautiful necklace of luminous, smooth cultured pearls that fastens with a .925 sterling silver clasp (\$295 suggested retail price). It is the necklace that never goes out of style. In a world where some cultured pearl necklaces can cost thousands, shop around and I doubt that you will see any jewelry offer this compelling!

Why would we do this? Our real goal is to build a long term client relationship with you. We are sure that most of you will become loyal Stauer clients in the years to come, but for now, in this lousy economy, we will give you these pearls to help with your future gift giving ideas.

We did find a magnificent cache of cultured pearls at the best price that I have ever seen. Our pearl dealer was stuck

A large luxury department store in financial trouble cancelled a large order at the last minute so we grabbed all of them. He sold us an enormous cache of his roundest, whitest, most iridescent cultured 5 1/2-6mm pearls for only pennies on the dollar.

But let me get to the point: this loss is your gain. Many of you may be wondering about your next gift for someone special. In the past, Stauer has made gift giving easier with the absolute lowest prices on fine jewelry and luxury goods. This year, we've really come to the rescue.

For the next few days, I'm not offering this cultured pearl necklace at \$1,200. I'm not selling it for \$300. That's because I don't want to **SELL** you these pearls at all... I want to **GIVE** them to you. This cultured pearl necklace is yours **FREE**. You pay nothing except basic shipping and processing costs.

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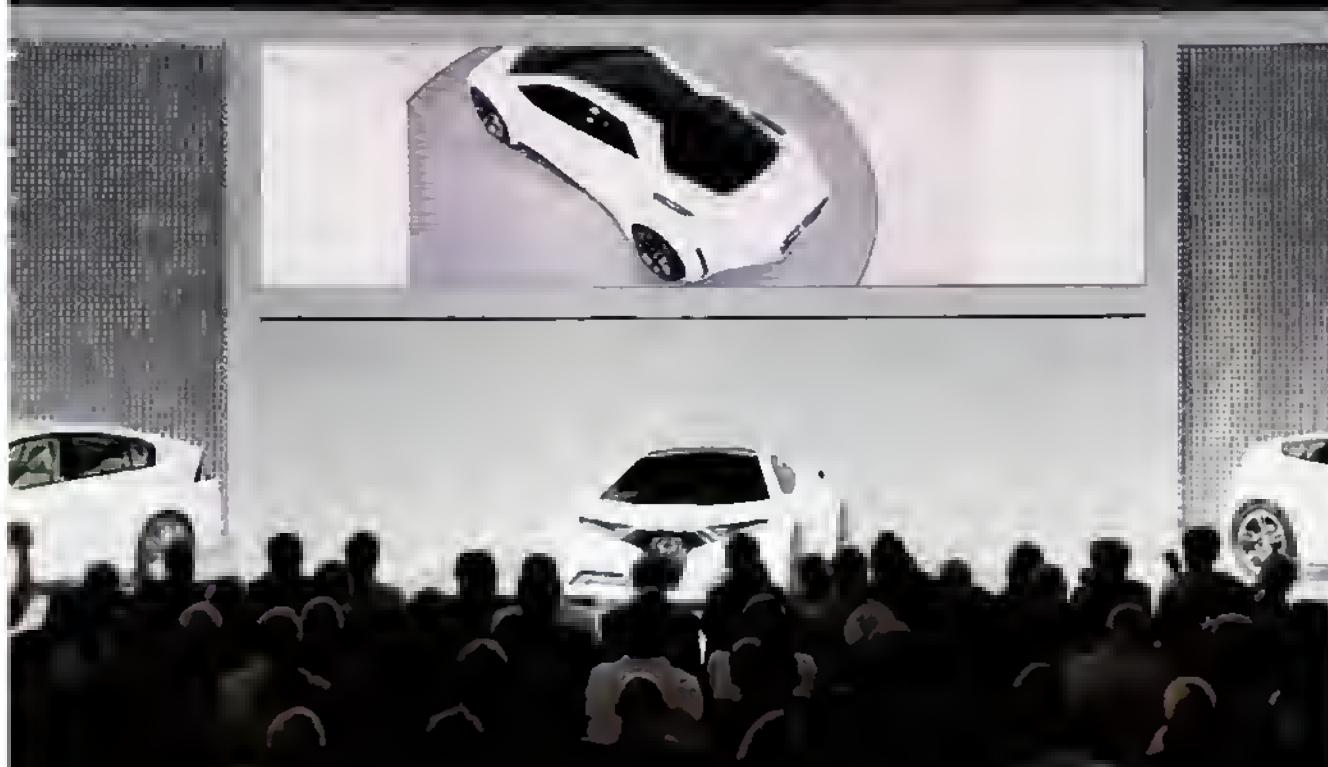


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LOS ANGELES : *Auto Show Special* : Honda FC Sport Concept



Future Eco Exotic

Last year, Honda's FCX Clarity gave us a glimpse into the world of fuel cell propulsion, but its tame sheetmetal belied the radical technology under the hood. The FC Sport, unveiled at the Los Angeles Auto Show in November, is a design exercise intended to push the boundaries of futuristic fuel cell packaging. The concept is a waist-high performance car with three staggered seats. The driver is positioned centrally. A fuel cell stack is situated between the rear seats, an electric motor rests just ahead of the rear axle, and a battery pack sits low in the middle of the vehicle for mass centralization. Could this concept become reality? Probably not in this form. But in a tough year for carmakers, it's nice to see designers still pushing the limits of the possible. —*BASEM WASEF*

Hollywood Stars

ECONOMIC TROUBLES KEPT GM AND CHRYSLER FROM SHOWCASING FRESH CARS IN L.A. BUT OTHER BRANDS BROUGHT NEWS OF FUEL EFFICIENCY AND FUN.



2011 Hyundai Hybrid

Hyundai finally has its own North American hybrid system. Hyundai's Blue Drive hybrid will debut on the next Sonata, with production to begin in late 2010. The system marries a 40-hp electric motor with a 2.4-liter four-cylinder. It's a parallel hybrid system, so the car can move via the gas engine, electric power or some combination of the two, and it uses a new lithium-polymer battery pack said to weigh 35 to 40 pounds less than conventional packs. Hyundai says the car can travel up to 20 mph and cover 8 to 10 miles on pure electric power.

2010 Lexus RX 450h

The all-new RX 350 and RX 450h are slipperier than before, with a 0.32 coefficient of drag. And that's impressive, considering the RX has grown slightly. The hybrid produces a total of 295 hp—27 more than the old RX. But the biggest development is on the inside. Lexus has finally joined the haptic controller race with a new computer-mouse-like system called Remote Touch. We can't wait to give it a try.

2009 Nissan Cube

Now we can officially strike one off the "cool cars we can't get in the U.S." list: Nissan's boxy B-car comes with a 122-hp 1.8-liter four-cylinder paired to a six-speed manual or CVT. Inside, novel features include a lounge-style rear seat. Highway fuel economy should exceed 30 mpg.

2009 Infiniti G37 Convertible

Properly proportioned convertibles are scarce—but this is one of them. This Infiniti is gorgeous. There's unique sheetmetal from the windshield back. It's powered by the same 3.7-liter 24-valve 325-hp V6 as the Coupe. And EPA mileage should approach 24 highway. Not too shabby.

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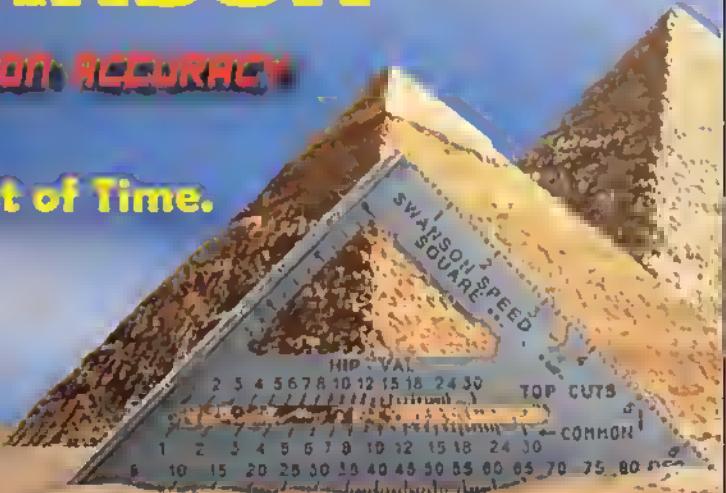
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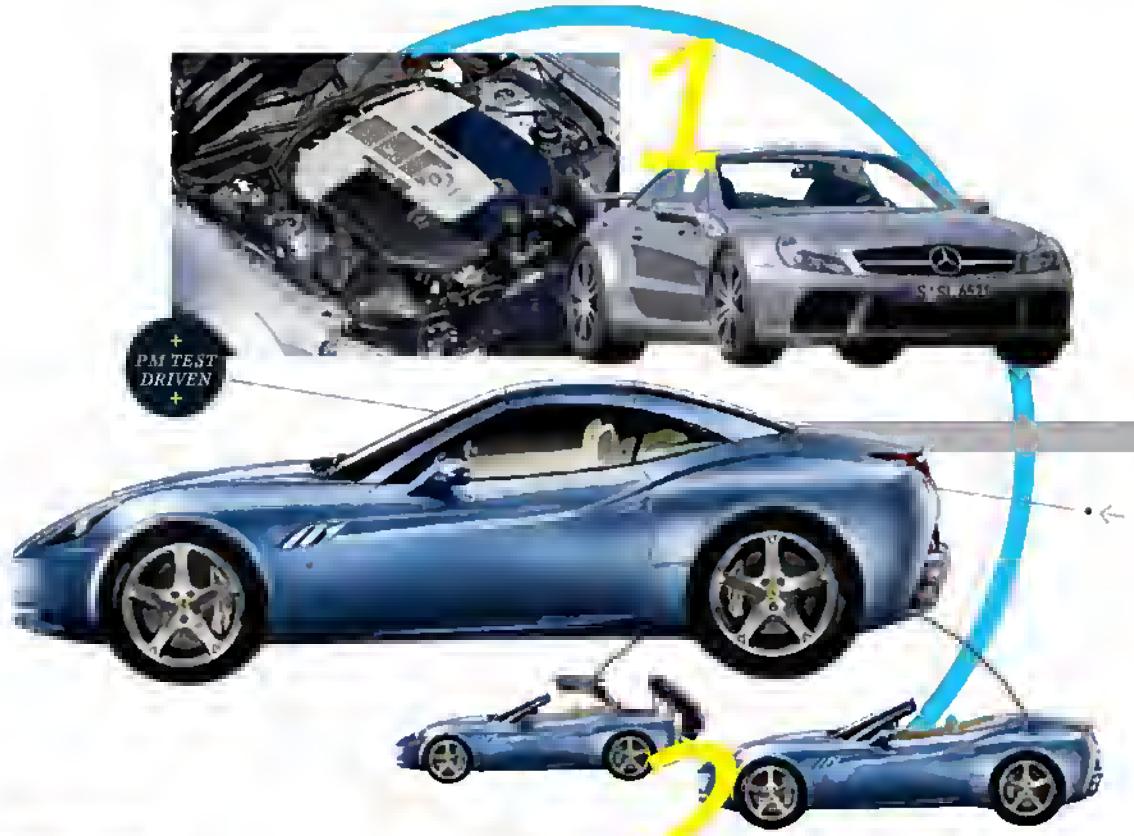
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1
2009
Mercedes-Benz SL65 Black Series

Track Star

We once thought the 638-hp Corvette ZR1 was the pinnacle of horse-power madness. But Mercedes has stormed right past that Vette with the 661-hp twin-turbo 6.0-liter V12 SL65 AMG Black Series—the most powerful car Mercedes has ever produced. The Black Series treatment turns already fast AMG cars into racetrack ready missiles. At around \$300,000, this one costs almost as much as three ZR1s. The Black Series shares only its doors and

sideviews with the SL, and, except for the rear fenders, the body is made from carbon fiber. Even the SL's convertible top was ditched for an aerodynamic fixed roof. Engineers yanked the SL's heavy and complex hydraulic suspension and swapped in a set of adjustable coil-overs. The suspension links were redesigned, and the mounting points moved to increase camber gain. Harder suspension bushings improve steering precision, and manhole-size brake rotors are fed by cooling ducts. At just 2200 rpm, the turbo V12 hits its 738 lb-ft torque peak and maintains that figure all the way to 4200. So just off of idle, there's

At the touch of a button, the Ferrari's aluminum roof begins a 14-second motorized pirouette, sliding both parts of the hardtop over the trunk space.

nearly five times the torque of a Honda Accord. Turbo lag? There simply isn't any. This car is explosively quick. The handling is nearly faultless, too, as we found at Mazda Raceway Laguna Seca. But just in case, there's a three-stage stability system. Our gripes are few—a somewhat spongy brake pedal and painfully slow shifts in the five-speed automatic. Hey, for 300 very large, we require perfection.

—LARRY WEBSTER

2
2009
Ferrari California

Old-World Charmer
In the '60s, only the wealthiest and most glamorous people in the world owned Californias. Now Ferrari is rekindling that spirit with a new \$200,000 two-plus two California, packing a 454-hp 4.3-liter V8. The seven-speed dual-clutch transmission is an engineering masterpiece. The cabin is fitted with creamy hides and expertly crafted trimmings. Peg the right pedal in Sport mode, as we did recently in Sicily, and this Ferrari comes alive. The muffler valves open, the gearbox sharpens and the engine emits a menagerie of growls, barks and howls. Now *this* is a Ferrari. —ANDREW ENGLISH



1

2009
Hyundai
Genesis

Big Luxe, Small Bucks

The Genesis is something of a revelation: It's the first rear-drive sedan Hyundai has produced for the U.S. and the first powered by an optional and robust 375-hp V8 engine, as well as the first Hyundai luxury sedan. That's certainly a lot of firsts. We wanted to see whether the \$38,000 car could hit the mark when it comes to bargain luxury and find out if that V8

would really return the sticker's promised 17 city, 25 highway fuel-economy rating. So we zeroed the trip meter on a Genesis, and hit the road for a weekend road trip from Detroit to Columbus, Ind. We immediately noticed the comfy leather seats, tilt-and-telescope steering wheel and the quiet cabin. The fit and finish inside the Genesis is quite good too. Over the 723-mile round trip—a mix of driving weighted heavily to highway cruising—the V8 Genesis returned 23 mpg. That's V6-level fuel economy in a V8 sedan. —JIM MCCRAW

2

2010
Audi
S4

Hot Flashes

Sound bounced off the tall stone walls along the single-lane stretch of tarmac in Majorca, Spain, where we were testing Audi's supercharged V6, amplifying the muted whine into a dull roar. We pulled back on the paddle for another instantaneous dual-clutch shift and pop from the exhaust. The \$50,000 S4 produces 333 hp and a relentless wave of torque. And that powertrain made this sport sedan incredibly capable on these very tight and very windy roads. Too bad we'll have to wait until fall for the car to arrive stateside. —JAMES TATE

3

2009
VW
Routan

Separated at Birth

Volkswagen, like everyone these days, is trying to do more with less. Call it corporate belt-tightening. So, to deliver a proper American-style minivan, VW went to Americans. The seven-seat Routan minivan, which in base S trim costs just \$25,390, is really a redesigned version of a Chrysler minivan. But even for those of us in the know, the improved steering feel, handling and ride help it stand out from the Chryslers. Now, when can we expect a diesel or hybrid version? —BARRY WINFIELD



1

2009
Yamaha
V Star 950

Cheap Thriller

Yamaha's Star division made headlines when it took the wraps off the nearly 200-hp VMax. But the \$18,000 pavement scorcher isn't exactly the best choice for commuters (or even most weekend warriors). It's just a bit too radical. In contrast to the mad Max, the V Star 950 combines a 942 cc V-twin engine with a low 26.5-in. seat height and manageable curb weight—making it a solid bike for intermediate riders or anyone wanting to downsize from

a heavyweight cruiser. We covered 120 miles of winding Georgia hill-country roads on the V Star 950, and came away impressed with this cruiser's ability to handle twisty pavement—pavement that was seemingly made for sportbikes. The riding position is relaxed, with legs stretched slightly forward and outward, due to the air box on the right and an engine cover on the left. Sweptback handlebars allow an easy reach for the grips, and foot controls are where you'd expect them. Clutch effort is very light, another plus for newer riders. Best of all, the V Star 950 starts at \$7890 and delivers an estimated 47 mpg.

—BASEM WASEF

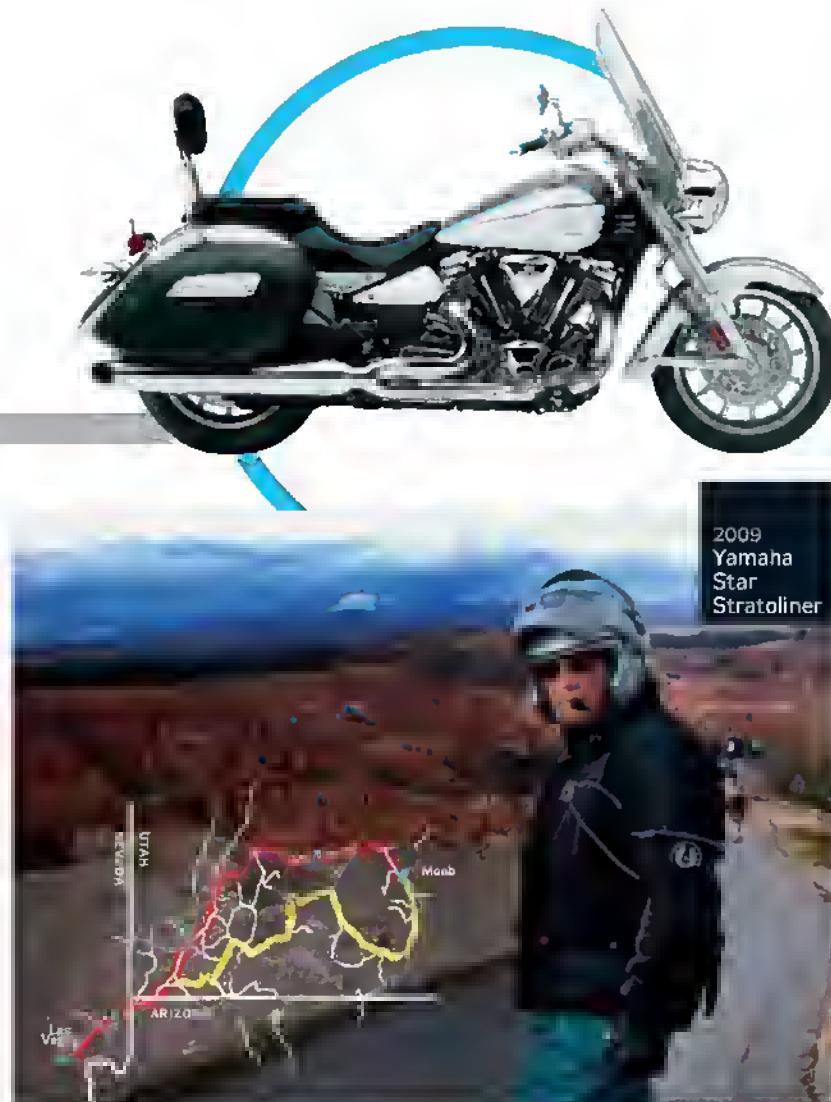
2

2009
Suzuki
Boulevard
C109R

Big-Bore Bruiser

The C109R is an unapologetically mammoth cruiser. The muscle comes from a 115-hp 1783 cc V-twin endowed with the fattest cylinders of any road-going gasoline vehicle. Woof. A dry weight of 787 pounds makes this monster feel like a two-wheeled Hummer. Yet the cruiser's \$14,099 price tag is a relative bargain compared to some Milwaukee-bred American iron. There's no avoiding the C109R's heft when you climb aboard. Lift the bike off the stand,

and it requires a serious push to bring this beast to vertical. On the other hand, the large, cushy seat sits only 27.8 in. above the ground—so the rider doesn't have too far to lift. Even at idle, the engine produces a mountain of torque. Just give the right grip a nudge, and the resulting thrust is so strong it's difficult not to break the speed limit very quickly. This surprisingly swift ride proves once again that it's fun to ride a really big cruiser with cylinders practically the size of beer kegs. —B.W.



- **Typical Route** / Miles: 457 Time: 7 hours
- **Mike Allen Route** / Miles: approx. 800 / Time: three days

Serious road warriors might yearn for a larger fuel tank. Despite returning 40 mpg from Moab to Vegas, the \$15,690 Stratoliner's small 4.5-gal tank meant we stopped for gas sooner than we wanted to.

the quick and boring all-freeway route. However, we rarely take the easy way. Our three-day odyssey covered a lengthy zigzag through southern and central Utah, exploring some of the nation's most awe-inspiring national preserves—Bryce Canyon, Natural Bridges, Zion—places that allow you to get so close to the scenery they make the Grand Canyon seem like a Hollywood set. The roads were challenging for the Stratoliner, a cruiser more suited for open highways than twisty mountain passes. Fortunately, the footboards hinge up when scraped, rather than grab pavement as some do. Even at 9000-plus-ft elevations, the big V-twin made plenty of torque to tame those switchbacks. Still, with views this spectacular, we weren't really in a hurry. The hailstorm was brief, and as the temperature rose we removed layers of gear—the bike's saddlebags quickly filled. On our last morning outside Zion, the freeze returned. We chipped a quarter-inch of ice off the bike, our own chilly bones warmed by an extra cup of black coffee. The Stratoliner was a smooth and stable companion all the way to Vegas. My wife reports the back seat is fit for a queen. Good news, because it's always important to keep your queen very comfortable. —MIKE ALLEN

Long-Haul Touring

THE BEST WAY TO SEE THE AMERICAN WEST IS FROM THE SADDLE OF A CRUISER. SO WE THREW A LEG OVER A 2009 STAR STRATOLINER AND HIT THE ROAD.

Outside Bryce, Utah, the temperature dipped into the low 40s and bullets of hail pelted my visor like angry wasps stinging an intruder. Suddenly, we were riding through a frigid downpour on Route 12 with less than 50 ft of visibility. Hey, wasn't this supposed to be the warm, dry American West? Luckily, my wife, Dale, and I are seasoned road-trippers armed with rain gear. So we just cranked the heat up on our electric vests and bore down. We were halfway through a sinuous 800-mile journey that would take us from Moab to Sin City through some of the nation's most breathtaking backcountry. These are views best experienced without fenders, doors or a roof—this is motorcycle country. Our steed? A 2009 Star Stratoliner—Yamaha's 99-hp 1854 cc flagship cruiser. This adventure could have been anything but, if we had chosen



2009
BMW
7 Series
Advanced
Electronics

+ PM TEST DRIVEN +

Speed Reader

The fifth generation 750i, as well as the 750Li version with its longer wheelbase, boasts more electronic advances—not to mention outright lavishness—than any BMW in the company's history. Would you believe this Bimmer can read? True. We spent time behind the wheel of the new six-figure 7 Series in Dresden, Germany, to test this very high-tech hardware in a very high-speed environment. Thanks to the silken 400-hp 4.4-liter twin-turbo V8, sporty suspension and comfortable seats, those autobahn miles passed with luxurious ease. —*BASEM WASEF*



The Manual

Tech innovations run deep in this new 7. And every one of them is documented in the owner's manual stored on the car's massive 80 GB hard drive. The manual offers animations, slide shows and audio, accessible via the improved iDrive controller. It all gets delivered to the driver on a brilliant 10.2-in. 1280 x 480-resolution monitor. That's halfway to HD quality.

Safety Check

A head-up display offers speed, navigation and—for Europeans only—speed-limit information. Yes, the BMW 7 Series can read road signs, thanks to character-recognition software and a small camera on the back of the rearview mirror. If signs are obscured, GPS takes over to provide the information. In the United States, this feature is at least a year away.

Night Vision

A new infrared night-vision system uses heat signatures and shape recognition to detect pedestrians walking alongside the road. If someone starts to cross the car's path, the 7 Series will alert the driver—well before that driver could see the pedestrian. The system is so sensitive that a 7 Series sitting in your driveway could detect areas of heat loss in your home.

iDrive 2.0

BMW's much-maligned iDrive controller has been simplified to move in four directions instead of eight and offers a menu "Back" feature and several buttons surrounding the controller to jump to often-used functions like "Radio" and "Telephone." Each one has a unique shape and location, so your fingers will learn them quickly. We found the new iDrive vastly improved.

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Subaru Forester 2.5XT Limited

As solid as the previous Forester was for toting kayaks and hauling a cabin full of hikers, it wasn't exactly a looker. Well, Subaru has fixed that with the 2009 Forester—it's the most stylish Subaru in years. And its engineers made sure to improve the practical

aspects of this cult favorite in equal measure. The new Forester grows slightly from the outgoing model. But that growth hasn't affected the Forester's maneuverability or its spunky persona. The XT models are by far the most fun. And that's why we

FIRST REPORT

chose to add an XT Limited to our long-term test fleet. The turbocharged 2.5-liter horizontal four-cylinder engine pulls hard. When paired with a four-speed automatic, as ours is, it makes this a very quick little crossover. Why shouldn't it be? Under that hood is the

VITAL STATISTICS Base price \$29,995; As-tested price \$32,420; Extra-cost options Bluetooth microphone, all-weather floor mats, puddle lights, auto-dimming mirror, satellite radio and trailer hitch; Drivetrain 2.5-liter turbo H-4, 4A, all-wheel drive; Engine performance 224 hp, 226 lb-ft; EPA fuel economy 19 city/24 hwy

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same motor Subaru installs in its high-performance WRX hot rods. And we have not babied this little wagon one bit—we're taking full advantage of the turbo's rush of torque at just about every stoplight. On our inaugural long-haul weekend trip to Pennsylvania, the Forester returned almost 25 mpg. Not bad, considering our lead-footed staff. It's worth noting, too, that the 225/55R17 tires help our Forester achieve 8.9 in. of ground clearance. That offers a level of security for those of us anxious to break out the Burton board and head to Vermont. One particular feature that should prove invaluable in winter is the smart rear wiper. Subaru has engineered it to switch from intermittent speed to full speed when the Forester shifts into reverse. That's handy if you're backing down a snowy driveway. We've noticed that the long-stroke suspension has improved the ride quality on our morning commute, too. Hey, in today's economy none of us can afford to spill one drop of Starbucks. —BEN STEWART



Our Forester XT may have a hot turbocharged engine under the hood, but in our testing so far, our best tankful returned almost 25 mpg. That's better than the EPA highway figure.



Nissan Maxima 3.5 SV

SECOND REPORT

Design is certainly subjective, but many of our normally auto-oblivious neighbors have commented on the crisp styling of our Maxima. We dig it too. The Maxima has drawn praise on more substantive issues, as well. This is a large sedan, meant to haul more than just the driver, so the ride in the rear seats matters. And those who have spent time back there have found the seats to be both capacious and comfortable. But it's the driver's impression that lingers in this car—and our Maxima continually impresses with its comfort and maturity. The Maxima's personality is like a less edgy, smoother and more, ahem, responsible version of the Infiniti G35. The handling is safe and secure, but this isn't a car that inspires a driver to probe the limits of adhesion. By driving smoothly, we've managed to nudge fuel economy to nearly 29 mpg on long trips. Aside from needing to top off all four tires to silence the tire-pressure monitoring system, we've had no problems so far. We haven't even needed to add oil. —MIKE ALLEN

DRIVERS NOTEBOOK

- The nav's user interface is blissfully simple in an era of counterintuitive, hard-to-program competitors.
- Getting the jack and spare loose from the trunk was a hassle even for a

big guy. Good thing we tried before we needed it.

- We like the instantaneous fuel-economy readout on the dash.

DATA SO FAR
As tested: \$37,550
Previous reports:

See 11/08

Miles driven: 3379
Miles since last report: 2101
Fuel economy:
Average—22.6 mpg,
Worst—18 mpg,
Best—28.9 mpg
Maintenance/repair: \$0

Mitsubishi Lancer Evolution MR

THIRD REPORT

The words "comfort" and "Evo" have never happily coexisted in the same sentence. The previous generation car was, well, rough—it rode like the springs and shocks were made of concrete. But our refined MR continues to impress. Two back-to-back trips from L.A. to Vegas confirmed that this track star is indeed well-suited to road trips. And it returned 22 mpg on those trips at a few ticks above the posted



speed limit. Speaking of speed, now that gas prices have declined, it seems folks around L.A. are back to their old tricks. We've been met at stoplights by all variety of hot rods—revving, snorting and challenging our Evo. Of course, we're above those sophomoric antics. But had we taken the bait, the Evo's low-end torque, all-wheel drive and quick-shifting SST gearbox would have trounced more expensive performance cars—like, say, one particular Ibis White Audi RS4. But like we said, we're above all that. —B.S.



DRIVERS NOTEBOOK

- We enjoy the engine's power and the sound of the turbo's boost building up. But the spoiler makes us feel like we're auditioning for the next *The Fast and the Furious*.
- One 6-ft 5-in. passenger was surprised at the generous amount of headroom in this compact. He was comfortable—all the way to Vegas.

DATA SO FAR

As tested : \$41,740
 Previous reports :
 See 08/08, 11/08
 Miles driven : 6619
 Miles since last report : 3861
 Fuel economy : Average—19.6 mpg, Worst—16.1 mpg, Best—23 mpg
 Maintenance/repair : \$105 (scheduled service)

PHOTOGRAPHS BY DAN CHAVKIN (LANCER), NOAH WEBB (VERACRUZ)



Hyundai Veracruz Limited

+ FINAL REPORT

DRIVERS NOTEBOOK

- The power liftgate is nice to have, but slow—really slow when you're waiting to load the skis in a snowstorm.
- The AM radio was briefly possessed by demons who grooved on pure static—then left. One reader e-mailed us with a similar complaint.
- One recall was handled at the most recent service.

END DATA

As tested : \$38,285
 Previous reports :
 See 04/08, 08/08, 11/08
 Miles driven : 35,437
 Miles since last report : 7117
 Fuel economy :
 Average—17.94 mpg, Worst—15.37 mpg, Best—20.84 mpg
 Maintenance/repair since last report : \$529.18
 Overall : \$982.06

All things—including comfortable, reliable things with heated leather, XM radio and separate driver, passenger and rear-seat climate controls—must come to an end. It's time to part with the Hyundai Veracruz after a year in which it made good on its promise to set a new bar for the marque and compete with (if not quite equal) the Lexus RX 350. From the start, we appreciated the interior details, which include easy-to-use controls and adjustable pedals. The vehicle gets high marks from everyone who climbs inside (up to seven passengers; only five fit in the Lexus). Driving performance has been respectable. The 3.8-liter DOHC V6 and six-speed automatic combine for easy passing, though acceleration from a standstill could be snappier—it was better when we handled the gearshifts in manual. Handling was as poised as the best three-row crossovers', the steering felt responsive, and we found the interior quiet on the highway, if a bit noisy over washboarded dirt roads. The Hyundai excelled in the snow—and in the shop, too. A recall involving a minor snafu with the transmission and clutch control unit was fixed promptly. We drove an insane number of miles (more than 35,000 in 12 months) and never needed more than scheduled maintenance. That helped seal the deal—in the Veracruz, Hyundai has crafted a keeper. —JERRY BEILINSON



COWS TO KILOWATTS

BY JENNIFER BOGO
PHOTOGRAPHS BY BEN STECHSCHULTE

At Hillcrest Saylor Dairy Farm in Rockwood, Pa., 600 cows produce both milk and the power to run the milking parlor.

Holstein No. 2699 gazes warily over Shawn Saylor's shoulder. The 39 other cows lining the stainless-steel stalls of the milking parlor at Hillcrest Saylor Dairy Farm appear unperturbed—by two strangers or by the vacuum pumps being swiftly attached to their udders. "They're very particular," notes Saylor, a fourth-generation dairy farmer. "Everything has got to be consistent." No. 2699 gives one last measured look from under long lashes, lifts her tail and ejects a stream of runny, brown energy that, very soon, will help power the farm.

Most people don't think of manure from 600 cows—18,000 gal, produced daily—as an asset; Saylor's neighbors in Rockwood, Pa., certainly didn't. Until two years ago, the waste was pumped to a holding pond on the property and spread on the fields every spring and fall. "You'd see a 2-ft crust floating down there that you could pretty much walk across," Saylor says matter-of-factly. "The odor was unbelievable."

A lot of people might not see a 50-gal drum of used cooking oil, flecked with bits of fried chicken, as a resource either. That's why I asked my uncle, Dave Hubbard, to drive me here from West Virginia in his biodiesel Jetta TDI. Uncle Dave converts the waste oil from local taverns into fuel to run his car, a motorcycle and tractors for five farms, so I figured he and Saylor could trade tips.

Saylor, 35, is both practical and inventive—much like Uncle Dave. Above the Leatherman clipped to his belt, the sleeves of a well-worn blue work shirt are rolled up to the elbows; his face dimples from smiling even as

FOR FARMERS OPERATING ON SLIM MARGINS, THE TRICK TO STAYING AFLOAT COULD BE UNDER THEIR FEET.

Truly Unique



Time travel at the speed of a 1935 Speedster?

The 1930s brought unprecedented innovation in machine-age technology and materials. Industrial designers from the auto industry translated the principles of aerodynamics and streamlining into everyday objects like radios and toasters. It was also a decade when an unequalled variety of watch cases and movements came into being. In lieu of hands to tell time, one such complication, called a jumping mechanism, utilized numerals on a disc viewed through a window. With its striking resemblance to the dashboard gauges and radio dials of the decade, the jump hour watch was indeed "in tune" with the times!

The Stauer 1930s Dashtronic deftly blends the modern functionality of a 21-jewel automatic movement and 3-ATM water resistance with the distinctive, retro look of a jumping display (not



True to Machine Art esthetics, the sleek brushed stainless steel case is clear on the back, allowing a peek at the inner workings.

an actual jumping complication). The stainless steel 1 1/2" case is complemented with a black alligator-embossed leather band. The band is 9 1/2" long and will fit a 7-8 1/2" diameter wrist.

Try the Stauer 1930s Dashtronic Watch for 30 days and if you are not receiving compliments, please return the watch

for a full refund of the purchase price. If you have an appreciation for classic design with precision accuracy, the 1930s Dashtronic Watch is built for you. This watch is a limited edition, so please act quickly. Our last two limited edition watches are totally sold out!

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he talks shop in the milking parlor. "There's a recycle-flush system here," Saylor says, activating a pump. Water recovered from other uses cascades across the floor, sweeping manure in murky streams down the length of the barn and into a tank at the mouth of an anaerobic digester.

Using common-sense engineering and some heavy machinery, Saylor has turned his operation's greatest drawback into its best feature: The digester transforms 8 million gal of manure and wastewater a year into electricity, bedding, fertilizer and heating fuel—saving hefty sums of money while also preventing emissions of methane and nitrous oxide, two potent greenhouse gases. As for

fetid odors, the farm's neighbors haven't complained in two years.

Gut Instinct

Harnessing bacteria to generate energy from waste is not a new concept: The first farm-based digesters in the United States were introduced during the 1970s. But because they required a large capital investment and energy prices dropped, few farmers pursued the technology. Now, with electricity deregulation, the tables are turned: Saylor is one of an increasing number of farmers taking advantage of state grant money—and a burgeoning private market for renewable energy credits—to develop alternative energy projects that, until recently, seemed out of reach.

Pennsylvania's Department of Environmental Protection awarded Saylor a \$600,000 grant, and Native

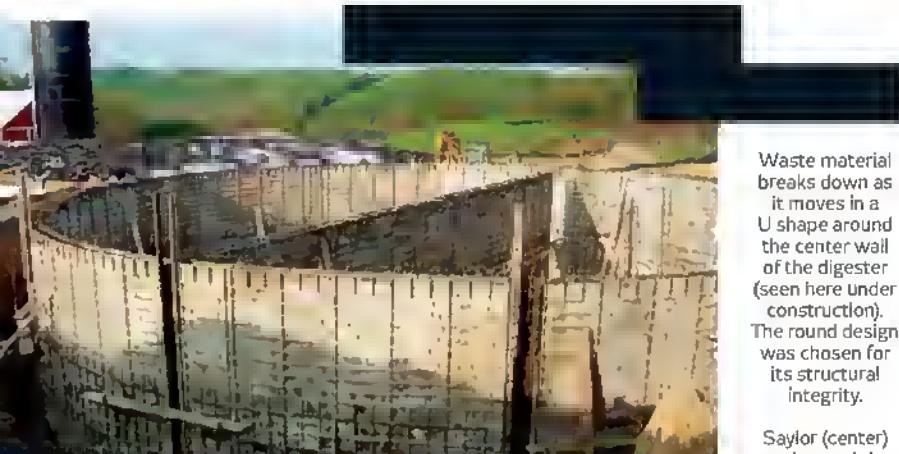
Energy, a carbon offset company, paid Saylor up front for the greenhouse gases a digester would eliminate over the next 20 years. But after visiting farms throughout the Northeastern U.S., Saylor wasn't satisfied with any one of the three most common digester designs.

"There were some things I liked about each of them, but there wasn't really a company that would build it the way I wanted it built," Saylor says. So he decided to combine the features that best fit the needs of his farm and save \$200,000 by doing all the excavating, plumbing, welding, electrical work and programming himself. Construction began in early 2006 and ended that fall.

Saylor and Uncle Dave discuss the merits of various fluids for radiant floor heating—Saylor installed pipes in the floor of the barn—as we walk toward the anaerobic digester. I'm standing on it before I realize we've reached our destination: a 70-ft-dia, 16-ft-deep concrete tank, capped by a lid and covered with soil so that it appears to be solid ground. The digester's influent tank, on the other hand, is impossible to mistake: Inside an adjacent outbuilding, a chute laden with cow manure is poised above a 19,000-gal tank holding a thick slurry of wastewater. The smell is so powerful that I involuntarily catch my breath.

The energy content of manure is relatively low—after all, it's already been digested once—so every week Saylor mixes in higher-energy food waste from the local potato chip factory. ("Sometimes I'll get, like, a truckload of cheese curls," he says.) Uncle Dave asks whether Saylor could get waste oil to make biodiesel too. "I asked," Saylor says. "It all goes out with the chips."

From the influent tank, the slurry disappears into the digester and begins to make a 16-day, U-shaped journey around a dividing wall. During that time, anaerobic bacteria break down organic matter, producing a biogas that is about 65 percent methane. "Basically, it's like a cow's stomach," Saylor says. "A big, efficient stomach." The gas, which fills



Waste material breaks down as it moves in a U shape around the center wall of the digester (seen here under construction). The round design was chosen for its structural integrity.

Saylor (center) engineered the heat exchanger to transfer heat from the engine coolant to water, or to a radiator that will supply heat for future forced-air composting.





the 12 in. of airspace under the concrete lid, is piped to another building for storage in a 40-ft-dia rubberized bladder. From there it drives a natural-gas Caterpillar engine, which in turn runs a 130-kilowatt generator.

In designs that don't provide methane storage, fluctuations in production may sometimes mean the generator is not running at full capacity, while at other times excess gas is wasted. Saylor opted for a bladder with 17,000 cu ft of capacity. "The bubble buffers me for a couple days," Saylor says. "I can run the generator at 100 percent all the time."

Closed Loop

Last year the system produced 1.2 million kilowatt-hours of electricity, enough to power the farm and several nearby homes, as well as their heat and hot water—saving about \$60,000. "It's covering everything, and there's still some left over," Saylor says. "We had 100,000 kwh last year that we didn't use." The local utility paid him 2.3 cents per kwh to put the excess into the grid. The digester also produces more gas than Saylor can use, so with another grant, he plans to install a second 130-kw generator this winter. All of that electricity will go into the grid—and when utility rate caps start to come off this year, it'll be worth even more.

A recent study from the University of Texas at Austin calculated that the 1 billion tons of manure produced in the U.S. annually could generate about 88 billion kwh of electricity—2.4 percent of annual consumption—and eliminate 99 million metric tons of greenhouse gases.

But digesters provide other benefits too. At Saylor's farm, waste heat from the engine saves fuel oil by heating the milking parlor and water for the farm, as well as water that runs through pipes inside the digester to maintain its 105 F temperature.

The watery waste that eventually flows out of the digester is pumped

The bladder holds 8 hours' worth of biogas, so Saylor can shut down the digester if he has to work on it. With a second generator, Saylor expects the \$800,000 project to pay for itself in less than five years.

to an anger-style compressor that separates the liquid from the solids. Earthy-smelling and soft to the touch, the solids displace green sawdust as bedding for the cows and, because they harbor less harmful bacteria than mill waste, are safer. Microbes in the digester have converted most of the volatile fatty acids into odorless methane, and so the liquid byproduct is far less potent. It is pumped to the holding pond and spread on the fields as fertilizer, where plants take up the ammonia nitrogen more quickly than the organic nitrogen in straight manure.

Every bit of efficiency helps, Saylor says. "Farming's a big gamble, from one end to the other. Yeah, we're still getting a decent milk price, but commodities are through the roof. Fertilizer is up 300 percent. It doesn't take long to burn up any money you've got coming in."

Uncle Dave nods. "And the cost of

diesel can really add up too."

"We buy a lot of fuel in a year's time," Saylor says. "A biodiesel system would work well here." If he can't get waste oil to make biodiesel like Uncle Dave, Saylor says, he could raise canola and press the oil himself. "Then," he says, still thinking out loud, "the cows turn the leftover feedstock to manure, the manure runs the digester and the digester makes energy for the process."

Some farms dabbling in biodiesel have gotten in trouble for dumping the glycerin byproduct, Saylor says, but he could put it in the digester.

"Or feed it to the cows," Uncle Dave suggests. "They love glycerin."

"They do?" Saylor asks, surprised.

"Oh, man. They think it's candy." Then he adds: "And you'll still get the gas out of it anyhow."

PM

 **ON THE WEB** > To drop into Dave Hubbard's shop while he converts waste cooking oil to biodiesel, go to popularmechanics.com/homebiodiesel.



NASA & ITS DISCONTENTS

FRUSTRATED ENGINEERS ARE GOING UNDERGROUND
IN A BID TO CHANGE THE AGENCY'S DIRECTION.
WHAT DOES THE REBELLION SAY ABOUT THE FUTURE
OF U.S. SPACEFLIGHT?

BY DAVID NOLAND
PHOTOGRAPH BY PHILLIP TOLEDANO

Late one evening in August 2006, Ross Tierney logged on to the chat room at *nasaspaceflight.com*, an unofficial cyberspace water cooler popular among NASA engineers. Tierney, a wiry 34-year-old space buff in Cocoa Beach, Fla., makes his living selling exquisitely detailed models of spacecraft and launchpads. He had been mulling over the design of the Ares I, the new NASA rocket that's slated to launch astronauts into orbit after the agency retires the space shuttle in 2010. Though NASA has been working on the Ares I since 2005, the new vehicle won't be ready until at least 2015. That leaves a five-year gap when there will be only one way to boost U.S. astronauts into space: Rent a Russian Soyuz rocket. And if Russia's current conflict with Georgia or some other international incident disrupts that

arrangement, the U.S. manned program will be grounded.

Tierney wondered whether the Ares I is really the best way to keep the U.S. in the spaceflight business. What if, instead of building a largely new rocket, NASA created a new configuration of proven space shuttle components and placed a crew capsule on top? Sitting on his living room couch, hunched over a laptop computer, he posted the question to the chat room. A dozen replies came back supporting the idea. "I was shocked," Tierney recalls. "Here I was, just a nobody enthusiast asking a dumb question, and a bunch of NASA engineers are telling me I was absolutely right. They said they'd been pushing the same thing for years and that they'd been threatened with their jobs if they kept talking about it."

Tierney's innocent query mushroomed into a credible challenge to NASA and its Ares I, which is already under construction. His original chat network has grown into an underground coalition of NASA engineers and contractors who, working on their own time, have come up with an alternative rocket design they call Jupiter Direct 2.0, or simply Jupiter Direct, because it is more directly based on shuttle components than the Ares I. The dissident moonlighters argue that their launch vehicle, the Jupiter 120, would be more capable and less expensive than the Ares I. Furthermore, they say their lifter could fly in 2013, trimming the impending gap caused by the shuttle's retirement. As a new presidential administration enters the White House, the insurgent engineers see a chance for change.

Last year NASA released a three-page, step-by-step critique of the Jupiter Direct proposal that challenged its claims. The dispute goes beyond engineering: Detractors' doubts about NASA's objectivity and professionalism strike at the foundation of the agency's reputation. Last October, NASA administrator Michael Griffin felt obligated to defend the agency during a speech at the American Astronautical Society. Regarding press coverage that implied NASA was capable of using "unfairly skewed" data, Griffin asked how it could be "presumed that NASA does not act with integrity ... is that what some people really believe?"

The Shadow of "The Stick"

These doubts come at a challenging time for NASA, as the agency moves forward on its ambitious plan to maintain the International Space Station, revisit the moon and, ultimately, send people to Mars. The economic crisis, growing tensions with Russia and political change in Washington are already prompting calls to rewrite the space agency's plan. Pundits and politicians have suggested extending shuttle flights beyond 2010 while pressuring NASA to speed development of the Ares I. In this environment, a rival plan promising a "faster, cheaper and safer" launch vehicle is as welcome as a pinhole in a spacesuit.

When NASA unveiled the Ares I in its 2005 Exploration Systems Architecture Study, it was already dubbed The Stick

BATTLE FOR THE FUTURE OF SPACEFLIGHT

With the space shuttle's imminent retirement, NASA needs a new way to get astronauts into space. The agency's proposed Ares lifters are being challenged by a plan called Jupiter Direct that proponents say would be faster and cheaper. Here's how the rivals stack up:

2010: Shuttle Retires

NASA originally planned to utilize components of the space shuttle on its replacement rocket, the Ares I. One of the solid rocket boosters (SRB) would form the new vehicle's first stage and the space shuttle main engine would power the rocket's upper stage. But during early development, NASA decided to use a new, less powerful upper-stage engine, which in turn necessitated a larger SRB. Jupiter Direct supporters say their concept is more cost-effective because it uses the off-the-shelf shuttle parts, such as the SRB and a slightly modified external tank.



PHOTOGRAPH BY GETTY IMAGES

2015: To Earth Orbit

The first requirement of a new launcher will be to deliver astronauts in the *Orion* crew capsule to the International Space Station. Jupiter 120 supporters claim it could get to the ISS by late 2013.

Ares I
NASA

Jupiter 120
Jupiter Direct

2020: To the Moon

Both systems require a second rocket to launch the Earth Departure Stage (EDS) into orbit, where it will link with *Orion* and the Altair lunar lander. Jupiter 232 proponents say it could be ready in 2017.

Jupiter 232
Jupiter Direct

Core Stage

Jupiter 120 would use existing milling machines to convert the space shuttle's external tank into the vehicle's body, thereby avoiding the cost of new manufacturing infrastructure. NASA says the performance figures and fuel-tank-conversion timeliness are too optimistic.

Engines

Jupiter 120 supporters say their rocket is cheaper because it requires no upper-stage engine for ISS trips, only for moon flybys and other long missions. The Ares I uses the J-2X engine, which must be built almost from scratch. But NASA says using its upper-stage engine for both ISS and moon missions saves money.

Solid Rocket Booster

The Ares I relies on a redesigned five-segment SRB; the Jupiter 120 deploys four-segment SRBs lifted directly from the shuttle. NASA officials say its larger SRB will be more economical to operate, even if Jupiter 120's hardware can be made more cheaply at existing facilities.



Ares V
NASA

Jupiter 232
Jupiter Direct

Payload

NASA uses only one rocket—the Ares V—to launch the Altair lander and the EDS. Jupiter Direct performs the same mission with two 232s: One for *Orion* and Altair; the other for the EDS.

Upper Stage

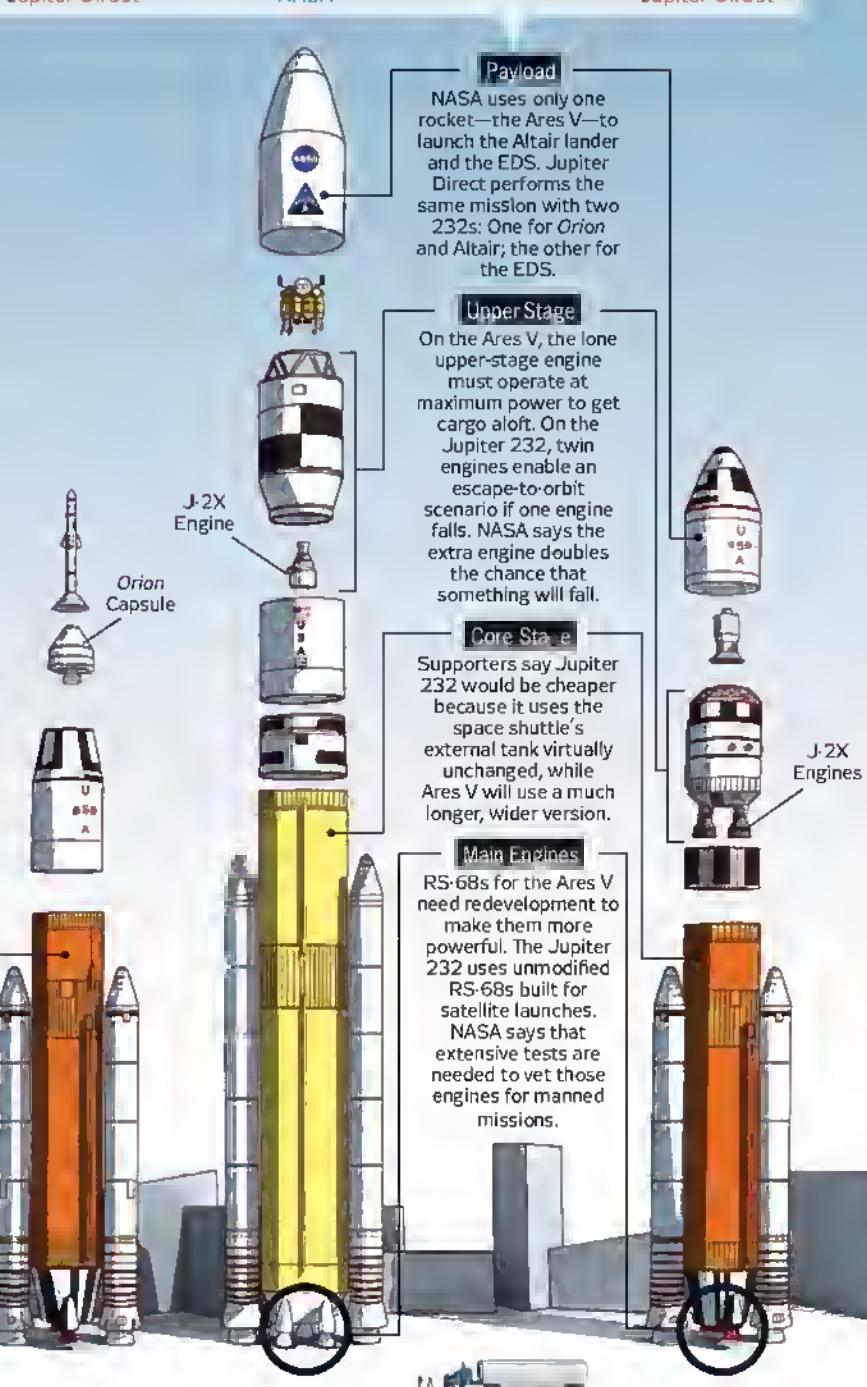
On the Ares V, the lone upper-stage engine must operate at maximum power to get cargo aloft. On the Jupiter 232, twin engines enable an escape-to-orbit scenario if one engine fails. NASA says the extra engine doubles the chance that something will fail.

Core Stage

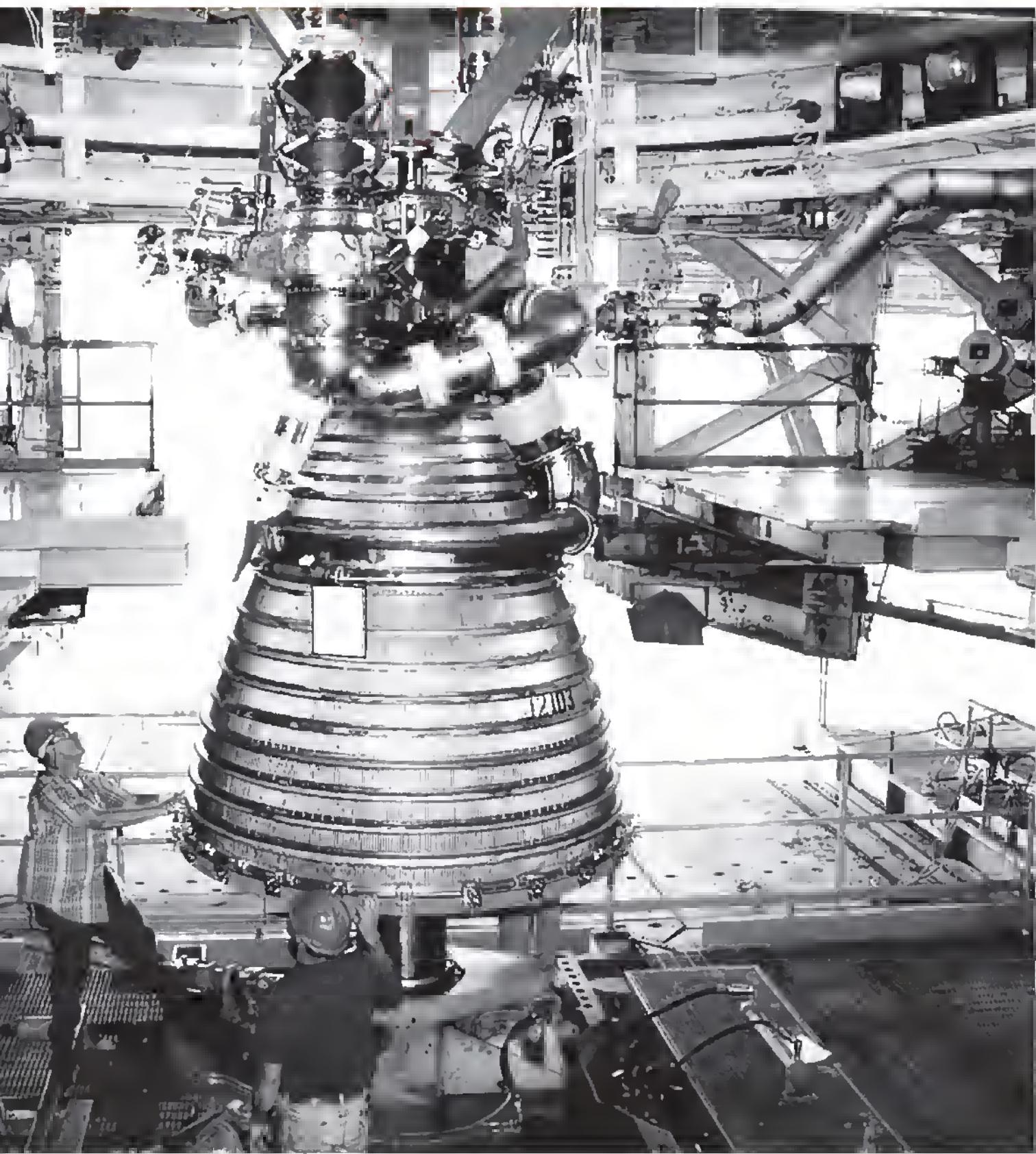
Supporters say Jupiter 232 would be cheaper because it uses the space shuttle's external tank virtually unchanged, while Ares V will use a much longer, wider version.

Main Engines

RS-68s for the Ares V need redevelopment to make them more powerful. The Jupiter 232 uses unmodified RS-68s built for satellite launches. NASA says that extensive tests are needed to vet those engines for manned missions.



Engineers at Huntsville, Ala., install a J-2X engine on a test stand, where it will be ignited. The new engine will propel the upper stage of NASA's Ares I and Ares V launch vehicles.





“While some pundits have opined that we will receive new direction from a future president or Congress, we will continue to follow the law of the land as it exists today, unless and until such new guidance is provided. I, for one, devoutly hope that we do not reverse course.”

For NASA administrator Michael Griffin, maintaining the momentum of the Ares program is vital to propelling U.S. spaceflight beyond low Earth orbit.

for its long, slim shape. The study, NASA's blueprint for future manned spaceflight, includes the four- to six-passenger *Orion* spacecraft and the Ares I rocket to launch it. Initially, the Ares I replaces the shuttle to take astronauts to the space station. For moonshots and other longer missions, the ESAS calls for a second launch vehicle to supplement the Ares I. Dubbed the Ares V and due for test flights in 2018, this massive unmanned vehicle will do the heavy lifting necessary for more ambitious missions. In NASA's plan, the Ares I would loft moon-bound astronauts into orbit in an *Orion* capsule. An Ares V would deliver the Altair lunar lander and the fuel-laden Earth Departure Stage (EDS). Once the three components—*Orion*, Altair and the EDS—link up in orbit, the combination vehicle would have ample power for extended moon missions. Similar configurations could travel to asteroids or beyond.

“In the beginning, all of us down in the trenches felt pretty good about the Ares I,” says a former engineer at NASA's Marshall Space Flight Center in Huntsville, Ala., who spent three years working on the rocket. (Because of continuing work for a contractor that has NASA as a client, he requested to remain anonymous.)

But then NASA senior management began changing the design. To save money, the efficient, well-proven space shuttle main engine that was to power the upper stage was replaced by the J-2X, which is three-fifths as powerful. Although the J-2X borrows its basic design from the J-2 used on the Saturn V, it is essentially a brand-new engine that requires a full development program.

To make up for the power loss, the Ares I's first stage—a four-segment solid rocket booster lifted from the space shuttle—had to be upgraded to five segments. “The net result of these two changes was a loss of performance,” the former NASA engineer says. The souped-up new booster ran into another problem—a jackhammer vibration called thrust oscillation that will require 6 tons of new hardware to dampen, reducing the rocket's payload by 1200 pounds.

Pet Project?

NASA is steadfastly sticking by its launch vehicles, claiming they remain the cheapest and fastest way to space. Before settling on the Ares I, NASA says it evaluated hundreds of configurations, including a rocket stack that is close to the Jupiter 120. But some within the space agency complain that the Ares I is a pet project of NASA boss Michael Griffin and former exploration chief Scott Horowitz. Before coming to NASA, Griffin, an aerospace engineer, co-authored a technical paper for the Planetary Society that proposed a rocket strikingly similar to the Ares I. Horowitz had previously promoted an Ares-like concept while a senior executive at ATK Thiokol, the manufacturer of the solid rocket booster that subsequently became the first stage of the Ares I. “The fix was in from the beginning,” says a NASA contract engineer involved in the process. “Other

EXPERTS WEIGH IN

configurations never had a chance."

Griffin declined an interview request from POPULAR MECHANICS. However, during his October Astronautical Society speech he challenged these negative images of NASA: "If it is not obvious that objective expertise underlies NASA decisions and actions, then the civil space program will grind to a halt in response to one searching examination after another by various other governmental entities which claim the right of agency oversight, and can make it stick."

Inside NASA, some disaffected staffers say they feel pressure to support the Ares I. The anonymous former NASA engineer says that there is a culture of intolerance for negative feedback among senior NASA management. "The attitude is, 'Do what I tell you, don't tell me what can be done,'" he says. "Data doesn't matter. All that matters is the decision that's already been made." The engineer says he received bureaucratic harassment for voicing concerns about the Ares I; last summer he decided to leave NASA.

Some veterans of NASA, such as former associate administrator Scott Pace, say that many young NASA engineers lack experience with developing new hardware. Instead, they have experience only in conducting research or in operating hardware that already exists. This, Pace says, adds to the "naivete" of those who feel their solutions are unheeded. "There were lots of these technical fights during Apollo," he notes. "What is different now is the modern communications and computational power on people's desktops. People can come up with plausible-seeming analysis and design in ways they couldn't during the 1960s and 1970s."

Those conditions helped Tierney's underground team find each other and form an upstart plan. The dissident engineers began to crunch technical and financial data to craft a detailed proposal. Meanwhile, a former Boeing engineer and software designer named Stephen Metschan was working independently on an Ares I alternative strikingly similar to the Tierney team's proposal.

Under a NASA contract, Metschan had created software to analyze rocket performance and fiscal feasibility. Using the software, his computer kept spitting out numbers that favored a vehicle similar to the shuttle stack configuration over the Ares I. Metschan presented a paper on his proposal at an aerospace conference in 2006; a friend of Tierney's happened to be in the audience.

Tierney and Metschan soon joined forces, combined the

If there's one thing the space community enjoys, it's a debate about hardware. But these experts note that budgets and other factors—not just engineering—will determine if the rebel Jupiter Direct plan will usurp NASA's Ares program to propel U.S. astronauts beyond Earth orbit.

Tom Jones

Former NASA astronaut, author of *Sky Walking*

Scott Pace

Director, GWU Space Policy Institute, former NASA associate administrator

I think it's great that the agency has the intellectual vigor to generate new ideas. But if you keep introducing instability into the program, you'll never get anywhere. As soon as you stop the momentum, NASA will be exposed to everyone who wants to mine its budget. The time to replace the shuttle is now. I don't want to start over again.

NASA designs fewer [spacecraft] now, and that lack of experience sometimes shows up as naivete outside the program or historical amnesia inside. Is there frustration when others don't see the brilliance of your ideas? Sure. If an engineer finds an answer, there is a willingness to believe it is the [only] answer.

best features of their two designs, and became the primary spokesmen for the joint project. Along with three other non-NASA engineering- and space-savvy co-authors, they presented a 131-page proposal at the 2007 meeting of the American Institute of Aeronautics and Astronautics. Since then, the number of secretly sympathetic NASA employees and contractors on the Jupiter Direct team has grown to more than 60. Some are frightened of losing their jobs, and neither Tierney nor Metschan knows the names of all of them. Tales abound of engineers punished for airing dissenting views and, even if the stories are exaggerated, the effect on staff morale is real. "Sure, I'm paranoid," one NASA source says. "If anybody found out I talked to you, I'd be blackballed."

NASA officials say that differences of technical opinions should be expected—and not taken personally. "A decision by a manager to follow one path rather than another is not evidence of 'stifling dissent,'" Griffin said in October.

Simple Design, Complex Debate

For all the trouble they're causing, the proposed Jupiter Direct launchers are not technologically revolutionary. Rather, they are a patchwork of pieces from current and past space programs. Indeed, the new plan

leaves the Orion capsule and lunar lander plans unchanged. The basic single-stage Jupiter 120, intended to replace the



Marco Caceres

Aerospace analyst, Teal Group

The strength of Direct for me lies in its simplicity and the overall weakness of Orion/Ares. As a market analyst, I would be more excited about Direct if I saw more dramatic cost differences. Proponents of Direct assume that Ares will have huge cost overruns, and I agree. But I also have to assume that Direct would have its own technical problems and cost overruns as well.

Ares I, is essentially a modified external tank from the shuttle powered by two RS-68s, the reliable liquid-fuel engine currently used in the Delta IV satellite launcher. The initial kick is provided by two four-segment solid rocket boosters lifted directly from the shuttle. "It'll deliver twice as much mass to the space station as the Ares I," Metschan says. While the Ares I is limited to low Earth orbit, the Jupiter 120's extra oomph would enable it to launch *Orion* beyond Earth orbit on a lunar flyby or on a visit to a near-Earth asteroid.

Lunar landing missions would call for a pair of medium-size, two-stage Jupiter 232s: One would carry *Orion* and the Altair lunar lander into orbit; the other, the Earth Departure Stage. Three RS-68 engines would power the first stage of the Jupiter 232; its second stage would rely on a pair of J-2X engines. Although the Jupiter 232 would not be as powerful as NASA's Ares V, Metschan says the two 232s could launch more mass toward the moon than the Ares vehicles. Jupiter Direct's backers estimate development costs for both its models at \$13 billion, compared to an estimated combined cost of \$25 billion for the Ares I and V. After a go-ahead, they say, the Jupiter 120 could be flying within four years, since its engines and boosters are available.

But the Jupiter 120 still faces two major technical hurdles: modifying the shuttle's external tank to form the main rocket body and certifying the RS-68 engines for manned flights. (NASA has more stringent criteria for space hardware used on those missions.) By contrast, the Ares I is essentially a new rocket requiring separate engine and booster development programs, including the J-2X; the Ares V also will require two additional development programs. Jupiter Direct's proponents say their system would fit neatly into the current manufacturing and launch infrastructure, allowing more of the

current shuttle workforce to be retained. The Ares I and V, on the other hand, will require two new sets of factories and launchpads. Metschan calculates Jupiter Direct's on-the-ground operating cost savings alone at \$2 billion a year.

NASA's attitude toward Jupiter Direct is understandably hostile. "We've looked at 1700 concepts since 2005, poking and prodding for a better way," says Steve Cook, the Ares program manager. He says a number of those concepts were similar to the Jupiter 120: "If we had found a better mousetrap, we would have used it." Cook insists that the Ares I will be cheaper than the Jupiter 120. "We've got a one-engine first stage and a one-engine second stage. That gives you lower recurring costs and a lower development cost." He dismisses the argument that the Jupiter 120 will save dollars during development because it is directly based on existing hardware. "Economically," he says, "the smaller vehicle wins," even with an all-new rocket.

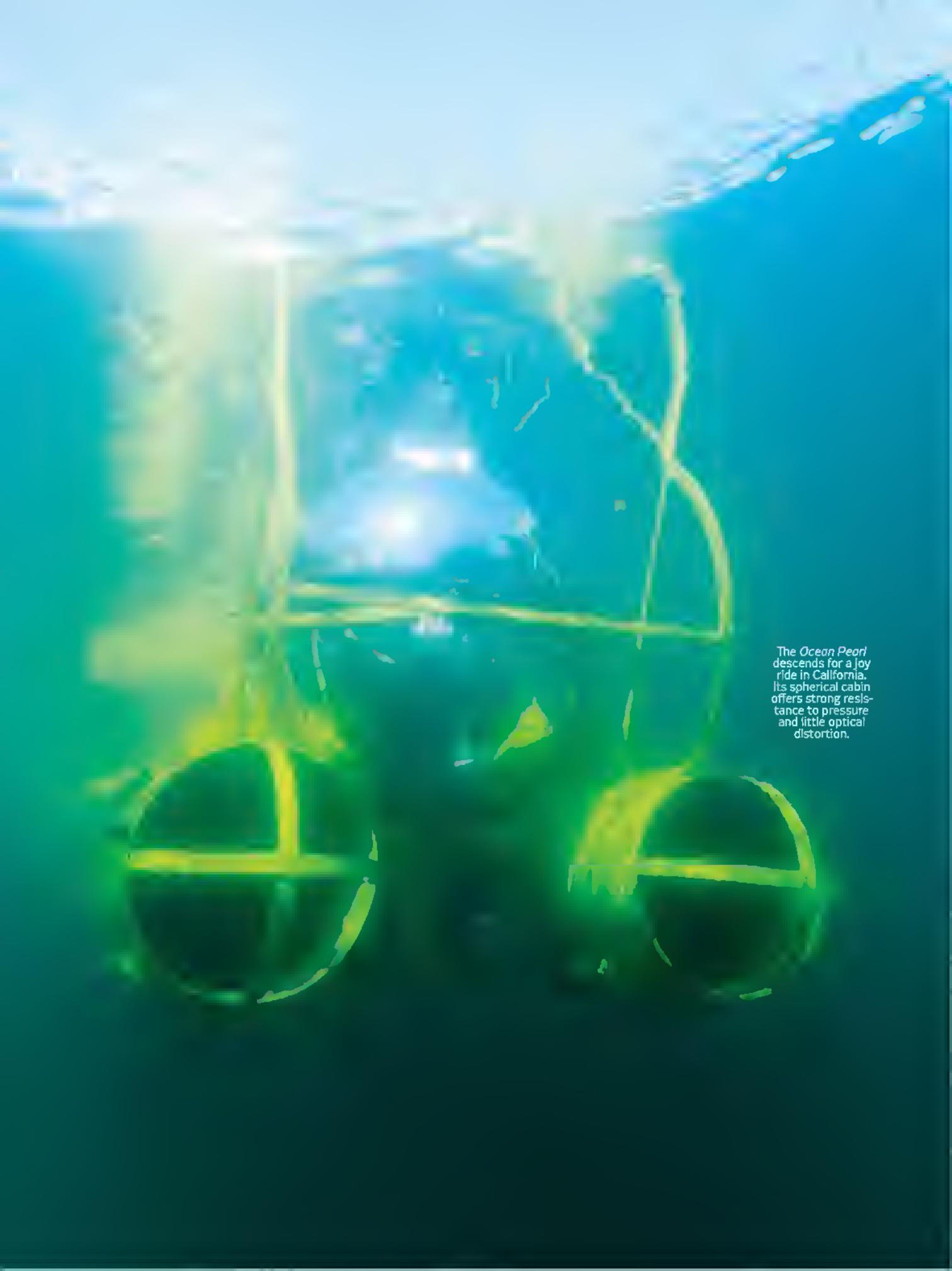
Cook's big objection to the Jupiter 120, however, is crew safety. Since the Jupiter 120 has twice as many engines—two solid boosters and two liquid-fuel core engines—he says there is twice the chance of a failure. Metschan responds that, given the Jupiter 120's huge excess lift capacity over the Ares I, engineers could outfit the *Orion* spacecraft it would carry with a blast-resistant shield to protect the crew in case of an explosion during launch.

NASA's Cook saves his most withering fire for the Jupiter 232. "When you run the performance numbers, the Jupiter 232 doesn't cut the mustard," he says firmly. Cook points specifically to the upper stage. "It's just unrealistically light for what it has to do," he says. "They're apparently building it out of unobtainium. If you use realistic numbers, their lunar lander mass goes down by 50 percent."

But Bernard Kutter, manager of advanced programs at United Launch Alliance, the Lockheed Martin/Boeing consortium that builds launch rockets, says that the Jupiter 232's upper-stage weight is "very reasonable. I'd even call it conservative." Kutter also spearheaded development of a cryogenic upper-stage design that the Jupiter 232 planners suggest adopting.

NASA backers say the entire debate is unfair: Ares is undergoing the challenges of a full-fledged development program while Jupiter Direct exists only on paper. Jupiter proponents can criticize every engineering trade-off NASA makes, while their own concept remains untested. All the while, the clock ticks down to the shuttle's overdue retirement.

As NASA faces an uncertain future, doubts over its direction are both expected and worrisome. The rebellion within NASA is not just about the volume of liquid oxygen tanks and calculations of thrust: The revolt arose from within the workforce, the most critical and least predictable asset of the space program. There is no algorithm that can measure the compulsion of engineers to question, tinker and argue. NASA may be finding that calculating the influence of celestial bodies is far easier than managing the human element. **PM**



The Ocean Pearl
descends for a joy
ride in California.
Its spherical cabin
offers strong resis-
tance to pressure
and little optical
distortion.

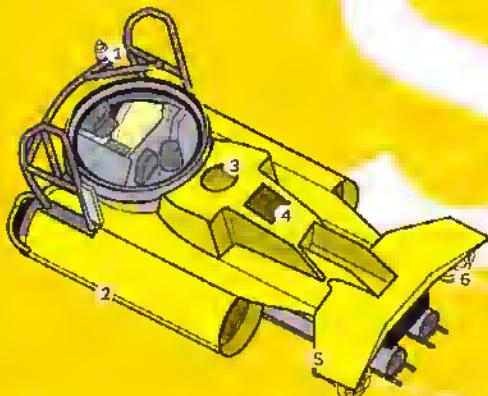


PHOTOGRAPH
Jad Davenport

DIAGRAM
Dogo

Personal

Subs



THERE'S A WHOLE WORLD TO EXPLORE
UNDERWATER, IF YOU HAVE THE RIGHT RIDE.

by Jeff Wise



NAME
Ocean Pearl

COMPANY
SEAmagine
Hydrospace

PASSENGERS
2

DISPLACEMENT
7000 lb

MAX DEPTH
500 ft

MAX SPEED
2.5 knots

ENDURANCE
Up to 8 hours,
with 72 hours of
life support

1. Sonar
A forward-looking sonar sensor is mounted near the front of the vessel. A screen in the cabin displays obstacles obscured by murky water or low light.

2. Flotation Bladders
On the surface, inflatable sacs provide the vessel with more than 30 in. of freeboard. When diving, the operator deflates the bladders.

3. Vertical Thruster
Located at the center of gravity of the vessel to maintain stability, this fan produces a jet of water that is used to control the depth of the submarine.

4. External Diver Station
A scuba-equipped operator can pilot the craft from a master control panel located outside the sub. This allows a pair of untrained occupants to ride in the cabin.

5. Buoyant Tail
The rear of the vessel is filled with foam to keep the craft in a horizontal pitch on the surface and underwater.

6. Aft Thrusters
Joystick-controlled thrusters push or pull the craft forward or backward, and can be used to rotate *Ocean Pearl* in place.



HE WATER IS RISING.
Already the murky, greenish sea is swirling around my feet, and it's coming up fast. Fortunately, I'm staying dry inside a 54-in.-wide watertight acrylic sphere attached to the front end of a 3.5-ton canary-yellow submarine built by an outfit called SEAmagine Hydrospace Corporation. This craft is the prototype for a line of personal vehicles that its makers say could change the personal submarine business from a fringe toy for the rich to an industry. "My long-term objective, in one word, is Boeing," says president and CEO William Kohnen, sitting next to me in the pilot's seat. "There's room for a company the size of Boeing in the undersea-vehicles market, and we want to be it."

Well, maybe eventually. Meanwhile, it's a perfect day in Southern California,



CONTENDERS IN THE RACE FOR **The Perfect Personal Sub**

all azure skies and crystalline sunshine, and a small crowd has gathered on the dock here in Huntington Beach to watch us slowly sink below the surface.

As the water laps over our heads, the dome vanishes, leaving the powerful illusion that I'm not in a submarine at all, but simply sitting underwater, perfectly dry. We descend slowly to the bottom and hover there. I lean forward and look down at the dark silt beneath my stocking feet. A mud-colored fish wriggles across the seabed, startled by our presence. Overhead, the sun is a quivering yellow-white blob amid the silvery underside of the surface. I expected the descent to be creepy or claustrophobic, but instead it's oddly serene, almost dreamlike. "It's not about getting from point A to point B," Kohnen says. "It's about the ability to hover, and take it all in."



tHE URGE to own and operate your personal submarine has long been a nearly impossible dream. For a century, subs have found widespread use as research and military platforms, but a market for leisure craft has remained elusive. Lately these watercraft have found a niche as playthings for the wealthy: A megayacht without a submarine is like an RV without a Weber grill. Russian oil billionaire Roman Abramovich has a two-man sub aboard his 377-ft yacht *Pelorus*, while Paul Allen's 413-ft \$450 million *Octopus* sports a 10-passenger model. Of course, with the worldwide supply of such billionaires a bit depressed at the moment, most personal-sub makers are hoping simply to hold on until the next economic upturn. If the high-end market can survive, technology and design developments might make these



NAME
C-Quester 3

COMPANY
U-Boat Worx

PASSENGERS
3

DISPLACEMENT
9259 lb

MAX. DEPTH
328 ft

MAX. SPEED
3 knots

ENDURANCE
Up to 6 hours,
with 96 hours of
life support

U-Boat Worx makes comparatively cheap subs by reducing the size of pressurized compartments, which leads to compact designs.

Instead of sharing a large dry space, the batteries, electronics and an air-conditioning unit each have their own small sealed compartment. The company's *C-Quester 3* prototype is as adept above the waves as it is below: A second outer hull makes the craft a sub-within-a-boat. Executives say they will introduce a three-passenger model this year that will cost about \$500,000.



NAME
OrcaSub

COMPANY
Sub Aviator
Systems

PASSENGERS
2

DISPLACEMENT
9000 lb

MAX. DEPTH
2000 ft

MAX. SPEED
At least 6 knots

ENDURANCE
Up to 12 hours,
with 96 hours of
life support

The *OrcaSub* is a submersible with wings. Sub Aviator's craft zips underwater much as an airplane flies—relying on forward motion to generate downward lift on two sets of winglike fins. A pair of thrusters mounted on the stern, each generating about 500 pounds of thrust, propels the sub at 6 knots. For close-in maneuvering, bow and stern thrusters allow the *OrcaSub* to rotate or move side to side. Sub Aviator plans to start building the first production model of the \$2.2 million *OrcaSub* this year with a construction time of up to 18 months.





Reverse fishbowl: Sub jockey Alfred McLaren pilots the *OrcaSub* on an undersea cruise in the Bahamas.

vehicles available to a lower tax bracket.

The technical challenges are formidable. Given the corrosive effects of seawater, the incredible pressures that build with depth, and the inherent danger, submarines are very difficult to operate safely and cheaply. Critical systems must be redundant, and structural components have to be engineered to withstand loads many times greater than those likely to be encountered. Add it all up, and submarines are heavy, complicated and expensive.

But that's changing as new materials like high-strength composites and titanium find uses in maritime construction. "It's finally got to the point where you can build a small, deep-diving sub for a reasonable cost, thanks to the digital revolution," legendary sub designer Phil Nuytten says. "We can fit all the electronics that used to be the size of a toolbox into a space the size of your thumb. Video cameras that once were 4 ft long and weighed 350 pounds can now be built the size of a roll of Life Savers."

tHE OCEAN PEARL's versatility doesn't just make for a thrilling joy ride for passengers like me. It's also been a boon for underwater researchers. One of the first customers to receive a SEAmagine sub was George Bass, founder of the Institute of Nautical Archaeology and the man behind the excavation of a half-dozen ancient shipwrecks in the Mediterranean. He's been operating submersibles since the 1960s, but SEAmagine's panoramic views blew him away. "It's just like you're sitting in your living room," Bass says, "except you're 150 ft down, watching the excavation."

Recreational sub builders still face

considerable hurdles. Maintenance costs alone can be expected to run on the order of \$30,000 a year. Between dives, many submersibles must be winched in and out of the water, and their batteries and compressed air tanks recharged. Rubber seals also must be inspected after each dive. Servicing a sub is an exacting and time-consuming process, requiring a skilled crew.

Indeed, some industry insiders are raising warning flags about the idea of selling subs for leisure. "They're marketed as toys," says Richard Boggs, technical superintendent at the yacht management firm Camper & Nicholsons International. "But a submarine is no more a toy than a helicopter is. They're very complex machines, and they require a high degree of technical competence and training to operate safely." Boggs has been working with submarine manufacturers and yacht managers to establish industrywide guidelines modeled after the ones used by commercial sub operators.

Beneath the waters off Huntington Beach, murky sunlight plays over the silty bottom. William Kohnen lets me take the controls. Maneuvering forward and to the side is easy, I find, but staying at a constant depth takes finesse. For safety's sake, the *Ocean Pearl* is positively buoyant—if power fails, it will float to the surface. To stay submerged, I have to toggle a thruster that pushes us down. The trick is, you have to anticipate the need well in advance. It's like flying a hot air balloon, but in reverse.

Soon I find that I've botched the timing, and the *Ocean Pearl* is accelerating toward the surface. The water above the canopy bubbles and froths, and the blue Southern California sky reappears, framed in aqueous silver. So it goes. Conquering the undersea world is a magnificent undertaking, I remind myself, but no one ever said it was going to be easy.

PM



If You Act Now...

PM BRINGS AS-SEEN-ON-TV PRODUCTS FROM
YOUR LIVING ROOM TO OUR LABORATORY, TESTING
CLAIMS TO GET RESULTS YOU CAN TRUST.
WE TRY 'EM—SO YOU CAN BUY 'EM (OR NOT).

Selling stuff on a TV infomercial is tough business. Thirty-nine out of every 40 television-pitched products fail, and the typical "success" stays on the air for a year, on shelves for another, and then it's over. Some retain brand recognition (ch-ch-ch-Chia!), but most, according to QVC founder and veteran producer Bill McAlister, head to that great big bargain bin in the sky.

Keep that life cycle in mind next time you're persuaded

by a "once in a lifetime" offer—you're better off buying later, when items hit store shelves, rather than forking over the shipping and handling charges tacked on to TV sales. Those fees multiply for every bonus item thrown in to sweeten the deal, setting the stage for online horror stories like "I Got Scammed 27 Times" and others posted by some less-than-satisfied customers.

But we like to make up our own minds. So with credit cards in hand, we ordered more than a dozen products that tantalized us and then subjected them to rigorous testing to finally answer that burning question: Do those things work? Here's the official PM response.



by **Harry Sawyers**
photographs by **James Worrell**

Shamwow

"YOU'LL SAY WOW EVERY TIME YOU USE THE SHAMWOW."

CLAIM:

Revolutionary fabric works wet or dry, acts like a vacuum to soak up spills and holds 20 times its weight in moisture. The machine-washable rayonlike fabric wicks liquid and air-dries quickly for reuse, saving big bucks on paper towels. **Eight for \$19.95***

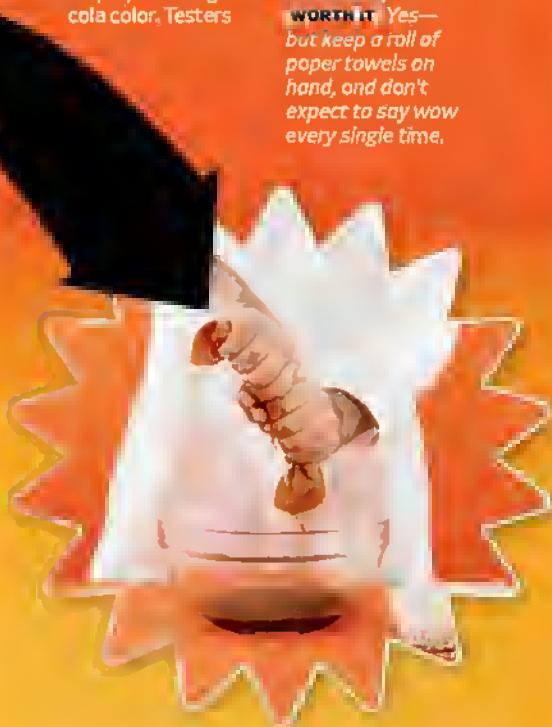
REALITY:

TEST Soaking soda from carpet, a spill from a plant pot, wiping countertops and drying off after a swim.

RESULTS After some wringing and pounding, a damp Shamwow soaked up everything from a soda-stained carpet, including the cola color. Testers

resorted to paper towels to fully dry a wood floor under an over-watered plant and a glazed ceramic countertop—but a butcher-block counter dried in one pass. The lightweight rag is backpack-friendly, but it's gritty and feels best on skin when patting, not wiping. Though it's meant to replace paper towels, pet owners could argue that certain spills really do require a disposable rag. You can wash it in the washer, of course, but that takes your go-to rag temporarily out of service. Machine-drying is discouraged, but it air-dries quickly and works quite well when damp.

WORTH IT? Yes—but keep a roll of paper towels on hand, and don't expect to say *wow* every single time.



StickUp Bulb

"JUST STICK UP THE BASE, SLIDE IN THE BULB AND YOU'VE GOT LIGHT!"



CLAIM:

A shatterproof, battery-operated light that you can install without an electrician. It's just a flashlight with a thimble-size krypton bulb in an acrylic shell repackaged in the shape of a light bulb. **Two for \$10**

REALITY:

TEST Navigation of an unlit coat closet and toolshed.

RESULTS "It's hard to get a true punch of light from something not plugged into a wall," says Shawn Tuddenham of bulb-monger whottwott.com. He's right: The StickUp's AA batteries generated 3.5 hours of wan light. The bulb stays cool to the touch. It is mounted with an included 3M adhesive strip or with screws; it also can be removed from the base to get closer to the action. PM's tests of LED flashlights suggest this product would last about 10 times longer if it used LEDs. We hope the StickUp men see the light.

WORTH IT? If you need a flash of light but aren't the flashlight type.

Pro Caulk

"ANY EDGE, ANY CORNER, ANY JOINT—PRO CAULK GIVES YOU A PERFECT FINISH IN MINUTES."



CLAIM:

"Sealing your bathroom can be a disaster," says the ad, revealing a wide shot of a man slathered in silicone. "Your fingers were never meant to be used like this!" Pro Caulk's three flexible polymeric disks use 12 corner shapes to smooth a bead of caulk to "a clean, straight finish—in minutes." **\$19.95**

REALITY:

TEST Applying silicone caulk over several exterior window casings, both in straight runs and in challenging corners.

RESULTS Pro Caulk worked as advertised. The 12 smoothing angles include crisp corners and chamfered angles to lay down fat and thin beads. Two of the 12 edges are "standard" rounded 90-degree corners. We worked with these two as a kind of hawk-and-knife pair. Interior corners came out much neater than when finger-applied. The ad promises "no wasted silicone"—that's possible, depending on your caulk-gun prowess, but not guaranteed. For most users, Pro Caulk will get much more caulk on the wall and a lot less wiped into a rag. **WORTH IT?** Yes—fills a void in the toolbox.

* Prices for all items in this article do not include shipping and handling.



Get-A-Grip
"THE REMARKABLE HANDLE THAT ATTACHES IN SECONDS—AND KEEPS YOU SAFE!"

CLAIM:

A telephone-shaped, suction-cup-powered plastic handle locks onto smooth surfaces to give you a grip. Two spring-powered, flexible plastic cups retract into concavity to grab a wall. **Two for \$19.98**

REALITY:

TEST Yanking the GAG from common bathroom surfaces.

RESULTS The GAG works on fiberglass tub surrounds and glazed ceramic tile squares larger than 4 x 4 in., but that's about all. Its instructions state that it is not safe to use on marble, granite, cement, cracked or painted surfaces, wood, rough/porous surfaces, weakened surfaces or loose tile. In the ad, a man climbs a boat on a GAG ladder—yet directions say the product is not safe for use outdoors. It must be used on completely dry surfaces, but we were still able to yank it off dry tile walls and glazed ceramic.

WORKS? *No. Major design limitations make installing a handrail the safer option. And don't pull a Spider-Man up the boat.*

**CLAIM:**

A carbide-edged blade saws through metal, masonry, tile, wood, pipe, glass and more. Carbide-edged reciprocating saw blades are nothing new, but this saw's multiple locking positions creatively repackage the idea. **\$19.95**

REALITY:

TEST Sawing through rusted 1/4-in. steel, copper pipe, brick and plywood.

RESULTS The ad claims the MXZ saw won't cut through your finger. That's true, and it won't cut much of anything else, either. Hard carbide abrades any of the materials listed, but the saw makes such slow progress through each, you'd save time even if you had to make a trip just to get the cold chisel, tile cutter or any other proper tool. A metal-cutting reciprocating saw blade, used by hand, smoked the MXZ saw in a speed trial on steel and copper. Cutting a brick was absurd, and 3/4-in. plywood has never felt tougher.

WORKS? *Nope. For one-tool-cuts-all solutions, stick with the hacksaw.*



Liquid Diamond
"IS WAXING YOUR CAR JUST TOO MUCH WORK? YOU RUB, AND BUFF, AND STILL HAVE WHITE STUFF EVERYWHERE!"

CLAIM:

Liquid Diamond, also sold as Instant Shine, resists mud and tar. "On a hot summer day, an egg just rolls away," and "not even fire can penetrate" its glaze. Silicone polymers

bond with the car's surface, keeping out dirt and grime to "lock in that brilliant, Simoniz shine." **\$19.95**

REALITY:

TEST Soiling a junkyard-taxi trunk top with mud and raw egg. Multiple attempts to set it on fire.

RESULTS A propane torch caused the paint to bubble, and a burning newspaper placed on the trunk caused indelible scorching. Mud and egg were more easily wiped away.

WORKS? *No. Advances in clear coats and wox have surpassed the wax-on, wax-off tedium of a carnauba coat. For a sterling finish without the work, try a combination "wash and wox" soap.*

Mighty Putty

"THE EASY WAY TO FIX, FILL AND SEAL VIRTUALLY ANYTHING FAST—AND MAKE IT LAST."

CLAIM:

A two-part epoxy "bonds to almost any surface," repairing leaks in metal, broken ceramic, gouged wood and more. Two-part epoxies are proven products that have been in use for years. This packaging combines an adhesive and a catalyst in a pig-in-a-blanket putty pairing. When mixed, the putty hardens into resin. **Six for \$19.95**



REALITY:

TEST Filling a stripped screw hole, sealing a leaking pipe, repairing a hole in a solid door, casting a new link in a chain and fabricating a new handle for a bottle.

RESULTS Two attempts to hang a concrete block from an MP "chain" failed immediately, despite 24 hours of cure time. Best results occurred when testers worked the putty until all traces of green disappeared—this could take up to 20 minutes, although the instructions claim an average of 2 minutes. That aside, stick with the directions: Apply to a clean surface within 2 minutes

after mixing; allow at least 1 hour to cure, and wear damp gloves as the putty can cause irritation. Pressing it into a stripped screw hole gave the screw new material to bite. We plugged a leaking PVC pipe, but fixing a dripping copper pipe failed. The owner of a formerly punctured door says, "It doesn't look like nothing happened, but it looks better than it did." In the ad, MP replaces a coffee mug's broken handle—we successfully fabricated a new handle to fit on the side of a glass bottle.

WORTH IT Far plumbing repairs and coffee-mug salvage, sure. Use real chains, though.

Samurai Shark

"THE ULTIMATE SHARPENING TOOL THAT PUTS A RAZOR'S EDGE ON DULL KNIVES, SCISSORS, TOOLS—JUST ABOUT ANYTHING WITH A CUTTING BLADE."

CLAIM:

"There's nothing more frustrating than trying to cut a ripe tomato with a dull knife." Tungsten-carbide sharpening edges, set at a unique angle, "give you professional results each and every time."

Two for \$10

REALITY:

TEST Cutting a dish sponge with a knife before and after the Samurai Shark treatment. Comparison cuts with scissors, pruners and a serrated bread knife.

RESULTS Before the SS treatment, the knife was too dull to sever the sponge. Afterward, it easily pared the porifera, but the abrasion left visible pitting and damage on the knife's edge. The V-groove sharpens at a bevel that may not match the knife's, and for nonknife jobs (scissors, axes, serrated blades and everything else the Shark sharpens) we dragged an X-acto-knife-size kernel of carbide freehand across the blade, risking injury. (Some similar tools have knuckle guards.) Master sharpener Darryl Hoffman of pro sharpening service The Knife Guys says tungsten-carbide sharpeners work "when you have absolutely no means of sharpening a knife. Even a badly sharpened knife is safer than a dull one."

WORTH IT Fine, if budget blades need a quick edge—just don't take it to the toolshed.



GRABIT and Drill-Out

"IF YOU'VE EVER STRIPPED A BROKEN OFF THE HEAD OF A NUT OR BOLT, YOU KNOW HOW FRUSTRATING IT CAN BE. WELL, NOT ANYMORE."

CLAIM:

The GRABIT—a damaged-screw-and-bolt remover—extracts problem fasteners in 10 seconds. Drill Out the damaged area with a cone-shaped end to form

a divot. Flip the tool around, drive in reverse, and the extracting head bites into the cone to remove the screw. The Drill-Out does the same for broken bolts.

Two sets of four for \$29.95



ON THE WEB >

See detailed tests of television's best and worst offers at popularmechanics.com/AsSeenOnTV.



Aqua Globes

"THE HAND-BLOWN GLASS ORNAMENT THAT WATERS YOUR PLANTS FOR YOU. JUST FILL WITH WATER, PRESS INTO THE SOIL, AND THAT'S IT!"

CLAIM:

You can't over-water; you can't under-water. Houseplants, patio plants, even "finicky exotic

plants" get the Goldilocks hydration. As the soil dries, oxygen enters the globe, displacing drips of water.

Four for \$19.95

REALITY:

TEST Giving relief to neglected, bone-dry indoor ivy.

RESULTS The Aqua Globe works, but don't just set it and forget it—you do have to refill the globe, after all. Two weeks after insertion, the ivy seemed to be doing well. The globe was emptied and refilled, the soil was lightly damp and the plant looked vivacious. Upon reinsertion, the stem clogged with soil and failed to release water. The instructions call for "a small stick or tool" to make a hole in the soil prior to placement.

WORST Yes, but better for vacationers than the forgetful.

Hercules Hook

"HEAVY OR LIGHT, BIG OR SMALL, IT HOOKS, HANGS AND SECURES THEM ALL."

CLAIM:

This hollow-wall fastener installs with no tools and holds up to 150 pounds—"Just push, set and hang." The "reinforced steel design" penetrates drywall and braces itself to the reverse side of the wall using a J-shaped leg. Downward pressure on the hook side increases the J-leg's grip behind the wall.

10 for \$14.99



REALITY:

TEST Removing new screws from hinge leaves, broken bolts from a lawnmower, stripped galvanized machine screws from a screen door and stripped decking screws.

RESULTS It went one for four. After boring a cone-shaped dimple with the cutting head, the reverse-threaded GRABIT pulled the machine screws from the screen door. But on the hinge leaves and the stripped deck

screws, the bit cut perfect, shiny cones, leaving the extracting bit no facet to gain purchase. With the Drill-Out, the bolts on the lawnmower were too skinny for the bit to stay centered. In fairness, there's no easy way to deal with a stripped screw—grabbing any exposed metal with Vise-Grips is still your best bet.

WORST Yes. A flush-driven stripped screw is nearly impossible to remove, and even getting one in four is better than nothing.



Fix It

"GOT SCRATCHES? DON'T GET FRUSTRATED, GET FIX IT! THE SCRATCH HAS MET ITS MATCH."

CLAIM:

A tube of liquid clear coat contains UV hardeners that allow it to "fill, level and cure!" Clear coat is paint resin without pigments. This packages that chemical in a tube like a marker.

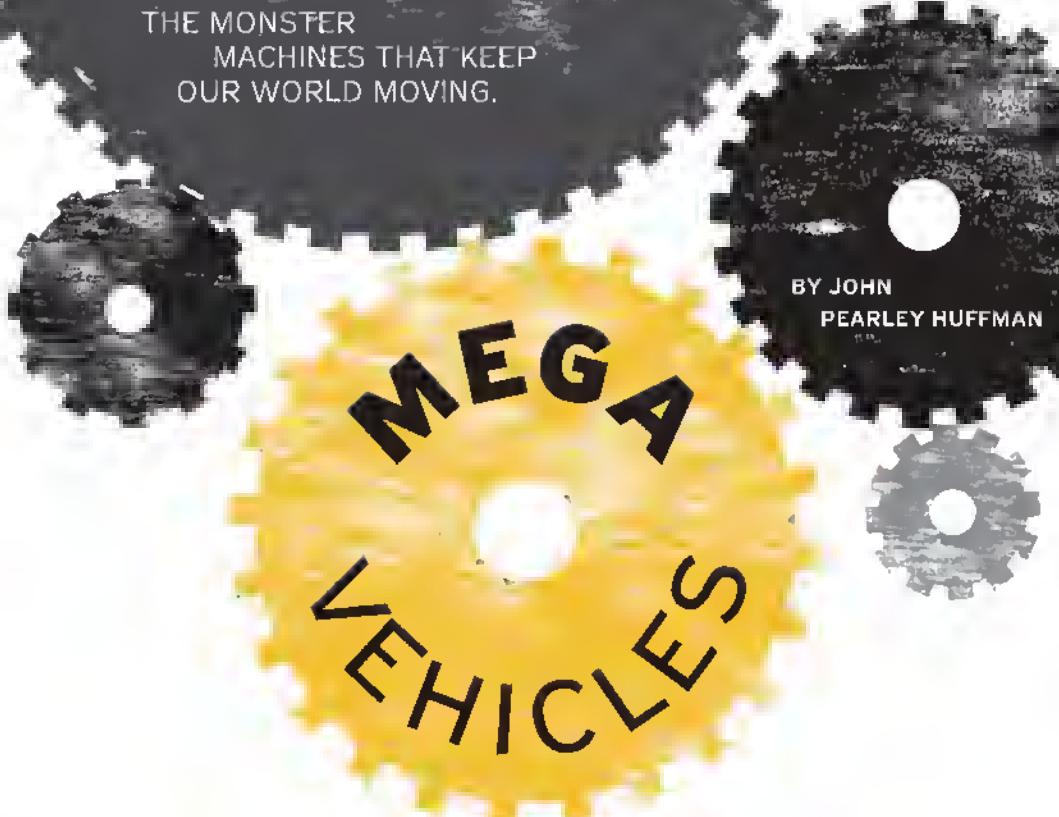
Two for \$19.95

REALITY:

TEST Smooth out key scratches in a late-model car.

RESULTS Scratches in the clear coat are superficial, and Fix It fills those in. For deep scratches in the paint—the ones you'd actually notice—Fix It is out of its league.

WORST Maybe touching up lightly keyed areas around locks could mitigate damage and buy some time before scratches become more severe.



THE MONSTER
MACHINES THAT KEEP
OUR WORLD MOVING.

BY JOHN
PEARLEY HUFFMAN



BIG MACHINES RULE THE EARTH. There are about 6.7 billion people on our planet, and they all need to be fed, housed, moved and supplied with power. These herculean tasks require either an army of small machines working independently or a handful of really, really big ones. And the bigger the scale of the job, the more efficient it is to go large.

These aren't megasize toys built to make adults feel like kids again, but serious tools to get serious work done in the quickest and most cost-effective way. You won't see these machines every day—or any day—unless your shift on the job involves processing hundreds of tons of ore, preparing for unthinkable huge disasters, assembling jet airliners or staring through space and time into the beginnings of the universe. But they are all machines that support and inform your life. Some day, they may even save it.

Over the past six months, PM has traveled the country in search of America's biggest and baddest machines. The scale of these monsters goes so far beyond our conception of large that you can't stand next to any of them and not feel completely overwhelmed. It's like gazing up at the Hoover Dam, the Empire State Building or Mount McKinley—it's impossible not to be intimidated.

But once we learned that these mechanical mastodons accomplish their megajobs with relative ease, they became surprisingly approachable. In some cases, we climbed up into the cab and learned firsthand from the guys who drive these vehicles how they operate and what training is required to earn that privilege. And on a few occasions, we were allowed to take command of the controls. Let's just say we'll never look at puny 18-wheelers or dinky backhoe loaders in quite the same way again. We've been supersized.

The Bridgestone/Firestone tires on this LeTourneau truck are 13 ft. 2 in. tall and 5 ft. 9 in. wide. Without protective chains, the 15,300-pound tires may only last six months. Replacement cost per tire: \$105,000.



PHOTOGRAPH BY JOHN BURCHAM

ASARCO'S OPEN-PIT Ray Mine in Arizona is so rich in copper that water sprayed on its dirt roads to keep down the dust instantly turns green as the ore oxidizes. If you stand at the bottom of the mine, which covers more than 50,000 acres, and look up at its high, tiered walls, you travel back in time to the top shelf, where the first cuts were made a generation ago by men with picks and shovels. Here at the bottom, though, the world's largest wheel loader—the LeTourneau L-2350—gulps 75 tons in a single bite.

The L-2350 is a 2300-hp monster. After tearing into the desert dirt a few hundred times, the steel teeth welded to the bottom edge of its bucket shine like silver. The machine's gaping maw is designed to dump rock and ore loosened by explosives into a seemingly endless line of huge trucks that haul it away for processing. Like most wheel loaders, the LeTourneau is articulated in the middle with massive hydraulic rams that pivot the huge hinge with 3400 psi. The Detroit diesel V16 is the size of a Ford F-350. At a governed 5 mph, the L-2350 burns through 1050 gal of fuel in 24 hours. This \$7.6 million machine

is so freakishly enormous that it was assembled on-site—and when its useful life is over, it will be scrapped on-site too. It will never have left the mine—from cradle to grave. Only veteran operators are allowed to handle the L-2350, and Ruben Rosalez looks the part. Rosalez, who started out working in underground mines and whose burly build, graying ponytail and weathered work clothes would look perfect atop a Harley, jokingly says his greatest qualification for operating the L-2350 is his "depth perception." But seeing him drive the monster using two joysticks—the left one controls the machine's movements, the right controls the bucket—is to see professional expertise become a mechanical ballet. My perch, a small jumpseat next to his chair, gives me a view of the 13-ft-tall, chain-wrapped tires from high above. "The chains aren't for traction," Rosalez says. "The tires just last longer this way." The whole machine is covered with the mine's dust—washing the L-2350 would itself probably yield a couple of pounds of copper. But we're here today to get that L-2350 a little dirtier. "The name of the game is to fill those trucks," Rosalez explains as he settles in and points to the line of dump trucks.



With that, the massive torque plunges the bucket's teeth forward, deep into the dirt. After scooping up the load, the LeTourneau rocks back on its haunches, all the while bounding on squishy side-walls like a coast guard cutter in constant 20-ft waves. And when Rosalez lines the bucket up to one of the trucks, it seems to exhale as it dumps the load. "I guess I'm used to the motion," Rosalez says, never losing his rhythm as he fills a truck in three scoops, then blows his horn to signal the next one over. "I don't even feel it. In fact, maybe I love it."

The LeTourneau's massive bucket is 24 ft wide. So, in a schoolboy's fantasy, it could easily swallow two 1970s Cadillac Fleetwoods piled on top of one another and lift the sedans 45 ft in the air before dumping them.



**LETOURNEAU
L-2350**

• Four-wheel independent-drive, rubber-tire, front-end mining loader



• 21 ft 2 in. at cab roof



• 293 tons



• 2300-hp
3967-cu-in.
diesel V16

Mega Factor
• Fuel tank holds
1050 gal



"SURE, THEY LOOK GLAMOROUS," says Portland, Ore., airport firefighter Pete Hallenius as his department's new "Slime Lime" Oshkosh Striker 4500 emerges from the fire station, "until you have to wash them." The \$1 million Striker 4500 is the airport's newest firefighting vehicle—a 58-ton colossus that can cross tarmacs at 70 mph to reach a burning aircraft and can fight that fire longer than any other Aircraft Rescue Fire Fighting apparatus. "We always know where we're going," firefighter Ken Edwards says as he moves into the center driver's seat. "Each of the trucks has its assigned spot if there's a crash. We don't leave anything to chance." I take a seat to Edwards's right, feeling the breathing apparatus in the backrest on my spine—it's there for a real firefighter in a real emergency, not for me. When Edwards fires up the Striker, the sound of the 950-hp diesel is muted; it rides back behind the 4500-gal

water tank. On the roof is a high-reach turret for spraying a fire from at least 230 ft away. In front is another turret—both are aimed and operated from the cab using a joystick. Under acceleration, the Striker feels quick. But what's most surprising is how it changes direction so effortlessly. If Porsche built a firetruck, it would have moves like this. Approaching the gas-fueled flames licking the fuselage of an aircraft mockup, the Striker brakes with uncanny stability despite all that water sloshing around. With a joystick controller in my sweaty palm, I aim the front turret and begin dousing the fire. When the pumps come on, the big diesel revs, and it's as if the Striker becomes one fiercely clenched muscle—the whole truck seems to be squeezing out water. And if water isn't enough, there's an onboard dry chemical system, Halotron I, and a foam system too. "We train every day," Edwards tells me. "And with any luck, we'll wear this truck out in training. Because the last thing you want is to actually need what this truck can do."



The Striker is designed to extinguish blazes, but with 17 in. of clearance, 16 in. of wheel travel and differential locks, it would be at home on a 4wd trail too.

OSHKOSH
STRIKER 4500
• Eight-wheel-drive
Aircraft Rescue Fire
 Fighting Apparatus

→ Height
• 12 ft 6 in.

→ Weight
• 58 tons

Engine
• 950-hp Cat diesel
with 2400 lb-ft
of torque

→ **Mega** →
• Sprays 1250 gal
per minute from
4500-gal tank



BOEING'S WIDE-BDDY airliner assembly plant in Everett, Wash., is the largest building on Earth by volume—472,370,319 cu ft. Big things here are almost pedestrian. Even so, the 118-ft-long, 32-wheel TLD DBL-110 cargo loader stands out. Way out. "That's DBL," chief operator Chris Dailey says, "as in Darn Big Loader." Actually, darn big is an understatement: This is the largest aircraft loader, period. The DBL-110 is the ground link in the supply chain for production of Boeing's new 787 Dreamliner. The manufacturing of 787s is global, so the challenge was to orchestrate final assembly in Everett. Suppliers fly in parts on a fleet of three modified 747-400s called Dreamlifters. The DBL-110 is then used to offload wings, fuselage sections and tailpieces through the swing-away tails of the 747s. The DBL's cargo deck is identical to the deck of the 747—whatever fits inside the aircraft fits onto the loader. Its cab is stuffed with monitors, hydraulic deck controls and a laser sensor that aligns the loader with the plane. However, it's the operator who

The 110-ton TLD DBL-110 loader can handle 68 tons of cargo. The deck, which is one-third the length of a football field, can be elevated to a height of 33 ft.

guides the loader up to the aircraft, not a computer. And the two vehicles never make contact. Freight moves from the plane's belly across an inch-wide gap and onto the loader's rails. With 32 wheels, 16 axles and six programmable steering modes, the DBL-110 is, yes, fun to drive. We very carefully drove it along Everett's runway aprons, and it's surprisingly simple to operate—pick the right steering mode, and it's nearly capable of rotating around its own center axis. Pick another mode, and the loader crab-walks. "Here, let's put you in the air," Dailey says as he raises the loader to its full 33-ft-high extension. The engines are now 30 ft below me, but the unladen DBL-110 remains stable and steerable. When you're hauling millions of dollars of parts along busy taxiways, it pays to be maneuverable.

TLD DBL-110

- Boeing Dreamlifter cargo loader

→ Height

- 33 ft with deck extended

→ Engine

- 325-hp twin Cat diesels with 1880 lb-ft of torque

→ Mega Factor

- Can move 68 tons of cargo at up to 10 mph

→ Weight

- 110 tons



It's just like the pickup in your garage—only this truck's torque equals that of a half-dozen semi tractors. The axle assembly (top) is the size of an F-150.

CATERPILLAR 797B

- Rear-wheel drive, six-wheel dump truck

→ Height

- 23 ft 3 in. (at roof)

→ Weight

- 687.5 tons

IN THE WORLD OF MINING trucks, there's an ongoing dispute about exactly which one is the largest. Many of these beasts are equipped with electro-mechanical drivetrains, like a locomotive. But not this massive Cat. The 797B uses the same kind of direct mechanical drive as, say, a Chevy Silverado. So in terms of conventional powertrains, this is the largest. "It's just a big yellow truck," says Mark Richards, marketing supervisor for Caterpillar's large mining trucks division. A big yellow truck powered by a V24 diesel that generates 3370 hp and a mind-boggling 12,170 lb-ft of torque. Driving the 797B is easy—once I get up the ladder that crosses in front of a radiator so massive it could double as a barbecue grill for the Jolly Green Giant. Inside the steel-fortified cockpit, I sit on a flat, squishy hydraulic seat facing a conventional steering wheel. My foot hits an accelerator pedal of normal proportions, and most of the instrumentation is familiar except for a digital readout that tells me how much tonnage is in the

bed behind me. The engine's air starter screams until the immense V24 rumbles to life. Put the seven-speed automatic into gear, and the truck initially lurches forward before lumbering off the line. It's then I realize that I'm almost 20 ft in the air, and what's behind me is three times bigger than any house I've ever lived in. The hydraulic steering has no feel, but it reacts quickly, and the 50 oil-cooled, 42-in. disc brakes could stop a runaway continental shelf. In fact, it's so confidence-inspiring that I'm tempted to become overconfident—not good when a mistake could mean picking the remains of my own Toyota Tundra out of the 797B's undercarriage. After thorough and thoughtful consideration, I think I'll keep my day job.

→ Engine

- 3370-hp 117-liter V24 diesel with 12,170 lb-ft of torque

→ Mega Factor

- 3 ft 6 in. of ground clearance

TELESCOPE MOVER

• 24-wheel, eight-wheel-drive mover

→ Height
• 15 ft

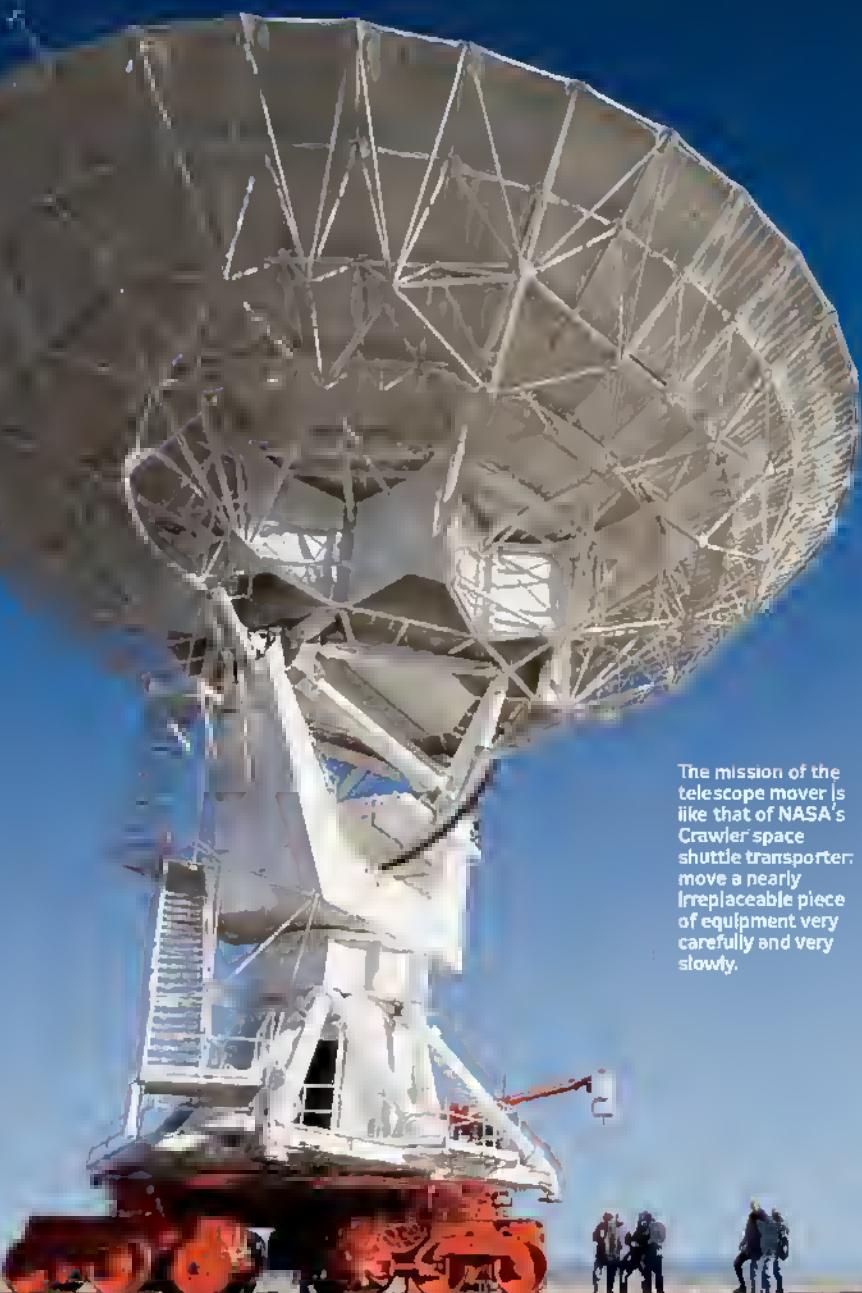
→ Weight
• 90 tons

→ Engine

• 400-hp six-cylinder Cummins diesel with 1000 lb-ft of torque

→ Mega Factor

• Three 90-gal-per-minute hydraulic pumps power four drive motors that move the vehicle over rails



The mission of the telescope mover is like that of NASA's *Crawler* space shuttle transporter: move a nearly irreplaceable piece of equipment very carefully and very slowly.

TELESCOPE MOVER

"THIS ISN'T LAB-COAT science," says one of the crew moving giant radio telescopes around New Mexico's remote Plains of San Agustin high desert. "This is blue-collar science—we're outer space's plumbers." Here, at the National Radio Astronomy Observatory's Very Large Array (VLA), astronomers look into the deepest parts of the universe using interconnected 82-ft-wide radio-telescope dishes. Arranged in a giant Y, the 27 dishes can be reconfigured using 72 different mounting pads along the lengths of the 13-mile-long legs. When it's time to reposition the array, the VLA's jeans-and-boots-wearing crews and two specially built movers swing into action as though they're switching lenses on a giant camera. Built in the 1970s as the VLA itself was being constructed, the two movers—known as the High Plains Lifter and Jack of Diamonds—ride atop two parallel sets of standard-gauge railroad tracks. The diesel engines turn hydraulic pumps that send pressurized fluid to four-wheel "trucks" that in turn propel the movers. The 230-ton telescopes are bolted atop the backs of the movers. At each mounting pad, a set of tracks runs perpendicular to the Y's leg. When a mover reaches that intersection, it stops and the crew goes to work ensuring it's perfectly positioned to change direction. Hydraulic pistons raise and turn the mover 90 degrees so that the crew can crawl underneath and align the truck to the tracks leading to the next mounting pad. Since the movers top out at about 3 mph, even a short trip takes hours; traveling the length of the Y can consume an entire day. While the mover's engine drones, the hydraulic system emits a low-grade hiss, and the steel wheels creak on the rails. But no matter how undignified the sound, the sight of a telescope moving through desert is simply, well, majestic.

PHOTOGRAPH BY JOHN BURCHAM

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PM Tool Test

Trim routers are easy to handle and work well for small jobs. Still, our test found that they complement, rather than replace, a full-size router.

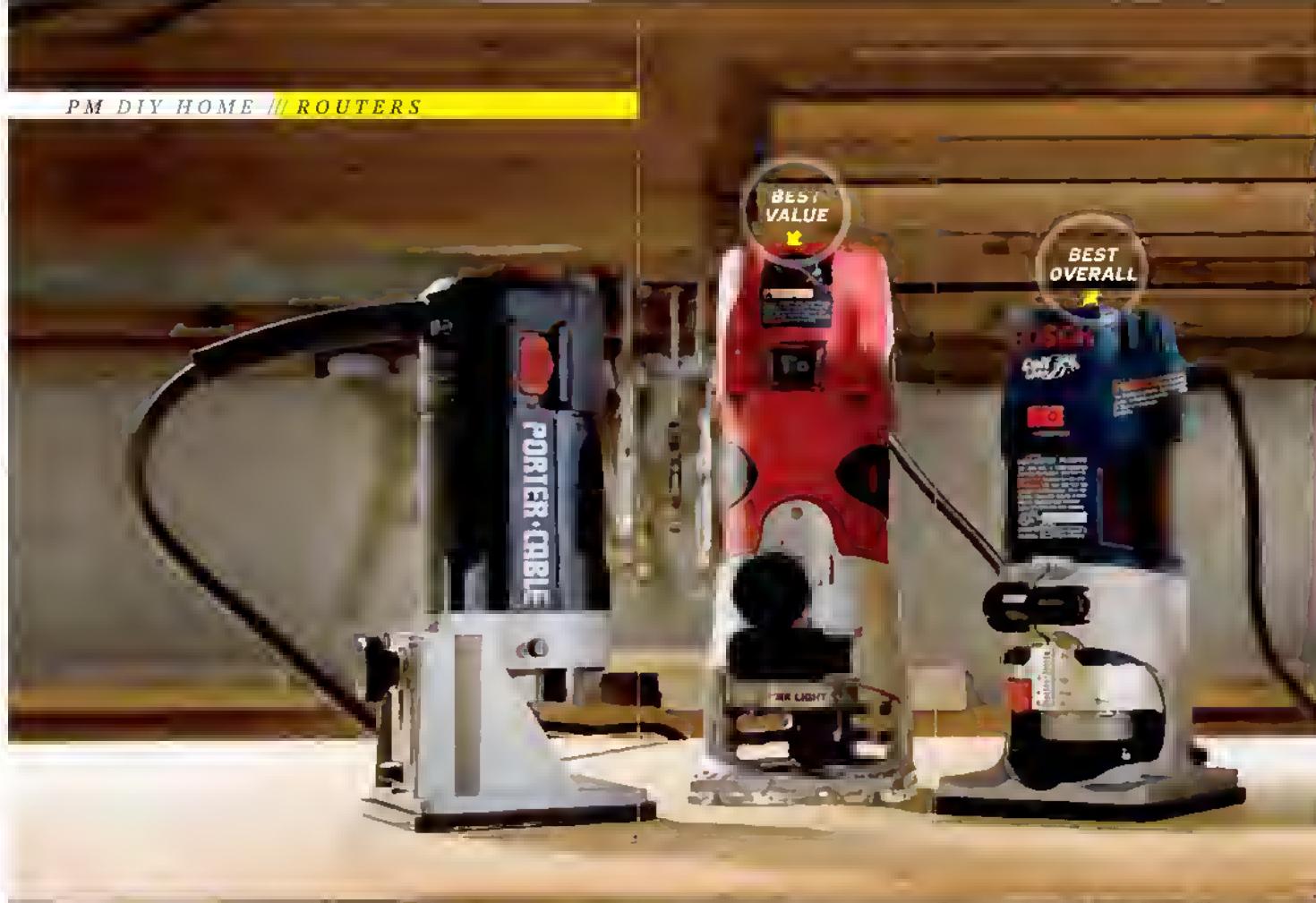
Groove Masters

TRIM ROUTERS ARE LIGHT AND HANDY. WE TESTED SEVEN—AND FOUND BIG DIFFERENCES IN DESIGN AND PERFORMANCE. *BY ROY BERENDSOHN*

The trend in power tools is to do more with less. Today's woodworkers are as likely to pick up a trim router to do a small job as they are to hoist a full-size router onto the workbench. Principally designed to trim laminate

but with the capacity to do light woodworking, these tools operate at speeds as high as 35,000 rpm. That's a lot faster than a standard router's 21,000 to 24,000 rpm. But can they do the work of a standard router,

even for small jobs? To find out, we gathered seven trim routers, and then three testers devoted a day to trimming laminate, cutting grooves and shaping the edges of oak boards. Here's what we found.



Price: \$219
Spindle Lock: Yes
Multiple Speeds: No
Soft Start: No

Porter-Cable 973

+ WHAT WE LIKED
 The Porter-Cable's no-frills design looks like it's 15 or 20 years old, but the tool works well. To adjust its bit, you tighten or loosen the large knob on the back of the base, setting the position of the motor, and hence the bit. Then, you use the fine-adjustment thumb wheel to tweak its position. Another nice feature that separates the Porter-Cable from the router crowd: a sub-base accessory for trimming the edge of plastic laminate so you can join adjacent sheets with a nearly invisible seam.

+ WHAT WE DIDN'T
 You'd think Porter-Cable would provide more than one speed, but it doesn't.

Price: \$110
Spindle Lock: Yes
Multiple Speeds: Yes
Soft Start: Yes

Craftsman 2312

+ WHAT WE LIKED
 Craftsman's engineers did their homework when they designed this tool. It's got everything: soft start, spindle lock, dial-adjusted speed control, a simple-to-use edge guide and a base that slips off in a flash. Testers agreed that its large auxiliary base with banana-shaped handles is superb. The base provides a wide, stable stance and keeps the operator's hands well away from the bit.

+ WHAT WE DIDN'T
 As curmudgeons, we look forward to complaining about something. In this case, we're stumped.

Price: \$190
Spindle Lock: Yes
Multiple Speeds: Yes
Soft Start: Yes

Bosch P20EV

+ WHAT WE LIKED
 The Bosch is a well-designed router for a variety of jobs, not just trimming laminate. It has the best depth adjustment in the test. Unlock its base clamp, slide the base to provide the desired height above the bit, then twist the fine-adjustment dial to perfect the base-to-bit clearance. It was one of only three routers where you can just slip the base off for bit changes or maintenance (the others are the Craftsman and the Ryobi).

+ WHAT WE DIDN'T
 Finally, it has the widest rpm range: 16,000 to 35,000.

+ WHAT WE DIDN'T
 We'd recommend a slightly larger base, to keep users from placing one hand too close to the bit.



DeWalt D26670
Price: \$84
Spindle Lock: Yes
Multiple Speeds: No
Soft Start: No

+ WHAT WE LIKED
The DeWalt is a good choice for basic router work. It's simple and it's got more than enough power to do the job. It has a simple slide-adjusted depth of cut control and a knurled thumb wheel for fine adjustment (as does the Porter-Cable, a product of its sister company).

+ WHAT WE DIDN'T
DeWalt (or Porter-Cable) should find a better way to mount the base to the motor so that you can slip the base on and off in seconds instead of fiddling with small parts. A tool this simple deserves simple base-mounting.

Makita 3701FC
Price: \$189
Spindle Lock: No
Multiple Speeds: No
Soft Start: No

+ WHAT WE LIKED
The Makita is the latest in a long line of the company's tools that reflect no-nonsense industrial tool design. Two examples are its top-mounted toggle switch and a thick 8-ft.-long rubber cord that connects to the motor with a heavy-duty strain-relief boot. Its collet is precisely machined, allowing bits to slip in and out and be tightened or loosened with ease.

+ WHAT WE DIDN'T
Somebody overlooked the fine-adjustment knobs, which are annoyingly small. Also, the shaft that connects the knobs is too short. One careless turn too many unthreads the fine-adjustment assembly, which then falls apart.

Ridgid 1200
Price: \$100
Spindle Lock: No
Multiple Speeds: Yes
Soft Start: Yes

+ WHAT WE LIKED
This is a pro-grade router. Take, for example, its ball-bearing edge guide. Attached to the fence, it helps produce precise edge cuts without the need to use a router bit equipped with a ball-bearing pilot. This enables a wide variety of routing operations with standard bits, and the guide's ball bearing is less likely to seize than a bearing on a bit, since it's farther away from the high-speed debris that comes shooting off a router bit.

+ WHAT WE DIDN'T
The fine-adjustment thumb wheel should be larger.

Ryobi TR45
Price: \$80
Spindle Lock: No
Multiple Speeds: No
Soft Start: No

+ WHAT WE LIKED
The Ryobi lives up to its billing as a miniature router, suited to light woodworking and laminate trimming. It comes with an auxiliary two-handle base that improves stability, and it's easy to set the cutting depth: Just flip open the adjustment latch and slide the motor up or down in the base. Like a full-size router, the latch allows the base to be removed quickly. That's handy on any router, but especially on those that, like the Ryobi, lack a spindle lock and require two wrenches to tighten and loosen bits.

+ WHAT WE DIDN'T
The crummy cord—it's as stiff as a piece of frozen rope.



Replacing a Staircase Handrail

SMALL CAN BE BEAUTIFUL WHEN IT COMES TO DIY PROJECTS—THIS UPGRADE WAS DONE IN A DAY.

BY JOSEPH TRUINI

I suppose I'm like most people when I consider home improvement ideas—I tend to think big: adding a master bedroom suite, building a multi-level deck, expanding the kitchen, replacing windows and doors, and other dream projects.

But over the years I've begun to realize that smaller, quicker projects can offer the greatest satisfaction—and the most impact for the money and time spent. For example, our current home has a beautiful red-oak formal staircase leading up to the second

floor. But for some incomprehensible reason, the builder mounted a plain pine handrail to the staircase wall, which is totally inappropriate. It didn't match the traditional oak handrail on the adjacent balustrade at all.

That handrail bugged me for years, as I went about larger projects. The last straw came when the rail loosened and threatened to come off the wall entirely. When it became hazardous, aside from being ugly, I realized that it had to go, and the sooner the better. I replaced it with a far more attractive railing that enhanced the staircase instead of detracting from it. Here's how I did it.

Out With the Ugly

The old handrail was attached to the wall with three cast-aluminum brackets, and as if the rail itself wasn't ugly enough, the brackets were painted black. So, the first thing I did was grab my cordless drill/driver and start backing out screws. I first unscrewed the brackets from the wall at each end of the handrail (1), leaving the center bracket for last. That way, the weight of the handrail was evenly supported until I backed out the last screw. Being a thrifty guy, I saved the old handrail to use on the basement or garage staircase someday.

Next, I checked to make sure the old brackets had been screwed to wall studs by tapping a finishing nail into the old screw holes. In each case I hit a stud, and knew that I could attach the new brackets to the same framing. I could have used an electronic stud finder to locate the nearest stud, but the finish-nail method is fast and sure, even if it is low tech. (Note that you should never attach a handrail to drywall or plaster using wall anchors; it must be securely screwed to a wall stud or other solid framing.)

Also, don't take a shortcut by installing the new railing using the old screw holes. Spend a few minutes placing new holes to ensure a really sturdy installation. I simply used a level to mark short vertical lines onto the wall, leading up from the bottom screw holes left by the old brackets (2). Then, I marked each of the three lines $\frac{1}{2}$ in. up from the bottom screw holes and

REMOVE OLD HARDWARE

(1) Use a fresh screwdriver bit to avoid stripping the slots in the old screw heads, which would lead to an ugly removal job. (2) Mark up from the old locations with a level.

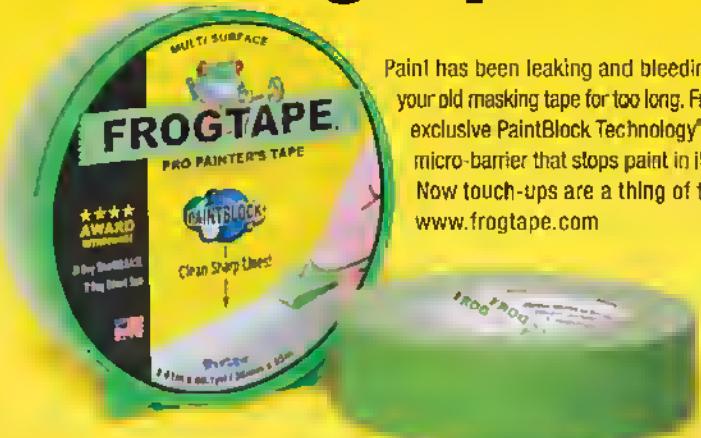


FASHION THE RETURNS

(3) Cut the short lengths of return and then cut the miter on the handrail itself. (4) Oak is tough stuff—don't even think of driving nails into it without first boring pilot holes. (5) Apply glue and nail the return.



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punched a small hole in the wall at each $\frac{1}{2}$ -in. mark using a nail set. These punch marks represented the locations of the bottom screws for the new handrail brackets. Moving the brackets up positioned the new handrail slightly higher than the old one, but it remained well within the recommended handrail height of 34 to 38 in. above the stair treads.

Next, I patched all the old screw holes with spackling compound. Once the patched areas dried, I sanded lightly with 120-grit sandpaper, spackled again, primed and painted. Since the handrail wasn't in the way, I painted the rest of the stairwell while I was at it.

Cutting the New Handrail

As a replacement for the pitiful pine handrail, I bought a handsome red-oak Colonial-style handrail at my local home center. It sounds high-end, but these attractive handrails are readily available and are usually located with other decorative wood products in the moldings aisle. And the new rail perfectly matches the oak handrail on the existing staircase balustrade. I paid \$6 per foot for a 15-ft-long piece.

The finished handrail is only about 13 ft long, but I needed the extra length to make the mitered ends. Known as returns, these are surprisingly easy to craft. Each one consists simply of a short, 45-degree mitered piece of handrail that gets attached to the long piece, so that it forms a 90-degree angle. The short length returns back to the wall, providing a nice, clean, finished look.

To start, I used a power

UPGRADE THE HARDWARE

(6) I chose glossy solid-brass railing brackets to set off the new rail. (7) Bore pilot holes into the handrail, then drive the brass screws through the strap and into the rail.



miter saw set to 45 degrees and cut a 3½-in.-long piece from each end of the handrail. Then, I cut opposing 45-degree miters on the handrail ends (3), making sure the last cut trimmed the handrail to its finished length measured from one outside corner to the other.

Next, I attached the returns to the ends of the mitered handrail using glue and a pair of 2-in. (6d) finishing nails. Because oak is too hard to nail through, I first bored 1/8-in.-dia pilot holes (4). Then I drove in the finish nails (5). I tapped the nailheads below the wood surface using a nail set.

Once the mitered returns were attached, I sanded the handrail with a random-orbit sander, starting with a 100-grit disc and finishing with a 120-grit disc. (When sanding, don't forget to hit the sharp corners on the bottom of the handrail.)

After wiping off the sanding dust with a damp cloth, I used a foam brush to apply a coat of Minwax Polyshades, which is a combination oil-based stain and polyurethane varnish. You could just brush on some varnish, or apply one coat of stain, followed by varnish, but I like the combined convenience, look and cost of Polyshades (\$12 per quart). Once the finish dried, I buffed the handrail smooth with superfine 0000-grade steel wool.

In With the New

The first step to installing a new handrail is screwing the brackets to the wall. Instead of reusing the old black-painted cast-aluminum brackets, I upgraded to a more elegant look and bought three polished solid-brass brackets that cost just \$7 apiece.

Starting with the bracket located at the bottom of the staircase, I aligned the bottom screw hole with the reference hole punched in the wall earlier. I used a drill-driver to fasten the bracket to the wall stud with the three screws provided (6). Then I moved on to install the bracket at the top of the staircase.

Now, before attaching the final bracket to the middle of the wall, I set the oak handrail on top of the two installed brackets. I screwed the U-shaped straps to the underside of the handrail, locking it onto the brackets, then installed the remaining hardware (7).

Once the handrail was securely attached to the brackets at each end, I installed the final bracket to support the middle of the handrail. Note that three brackets are required for handrails longer than 8 ft.

The fresh paint and the new rail really dressed up the house's front entrance. I don't know why I waited so long—all it took was a few hours over the course of one weekend. PM

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by Roy Berendsohn

Q+A



Making an Entrance

Q Our house has no overhang or protection from the weather at the front door. We want to add a covered entry area. Can you offer some advice?

A It's surprising how many houses have either no covered entrance at all, or else one that's merely decorative and offers no real protection from the weather while you fumble with your keys. I think it stems from builders trying to save a few dollars on construction. My first piece of advice would be to make the overhang large enough to do the job. It should be able to accommodate two people—and keep them covered while one person

stands to the side and the other one swings the front door open.

Next point: Provide adequate lighting. A cover will darken the front entry area, which can make a house seem sinister and uninviting at night. That's easily corrected, though. Ideally, you will install a fixture on the ceiling of the entry, but a pair of lights on the wall of the house, flanking the front entrance, will supply enough light. If you're doing the electrical work yourself, and you

Network Interface Device

Recently, I had a phone problem, so I went outside and plugged my landline phone into the phone service box to check whether the problem was in the house or with the phone company's equipment. I found that the inside of the phone box was dirty and the parts corroded. When I was visiting my girlfriend, I glanced at the box for her cable service and it was stuffed so full its door wouldn't shut properly. Should I complain to the phone company? Should my girlfriend call the cable company?



The answer is yes on both counts. In most cases, the phone company is responsible for the box at your house, known to technicians as a demarc box for the demarcation point where the phone network meets your house system. (It's also called a network interface device.)

The cable company is another matter. You may have a hard time convincing the company to replace its equipment, often simply called a house box. I've seen several with this problem. I suspect the company chooses the least expensive box that works—one that doesn't provide for adequate cable bend radius and connections. Even if it does no good, call and complain; the gap at the door can lead to a system failure.

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plan to mount the lights to the front of the house, you might find it easier to make a mounting block for the lights. Fastened to the house's sheathing, the block will provide a flat and secure mounting surface regardless of what kind of siding you have.

In all other respects, building a covered entry is like undertaking any other construction project. The structure needs to be supported on a foundation that reaches below the frost line, and it must conform to the building codes in effect where you live.

Lean and Mean

We have a large old shed on our property that leans to one side. Can it be fixed, do you think?

Well, any building can be repaired. The question is whether it's worth your time. Here's what to look for to help you make the right call.

Aside from its lean, does the building also have a sagging ridge line and

wavy walls? If so, tear it down. The case is closed—especially if any of that damage is due to rot, termites or a completely crumbling foundation. You might be able to reclaim some of the lumber after dismantling the structure, but think twice if there's termite damage—you don't want to transport the infestation into a new building.

On the other hand, you should be able to save the building if the lean is uniform, the walls are straight and the foundation is still sound.

Here's the tricky part: pulling the structure into shape safely—and then fastening it so it stays put. Although a small amount of lean can be corrected with steel cable and nothing more than a large turnbuckle purchased at a hardware store, in most cases you'll need a heavy-duty, lever-powered winch (a come-along) or an electric winch.

To correct a steeply leaning building, fasten the come-along or winch's cable on a high corner of a leaning wall and

lead the cable diagonally to the low corner on the opposite side. You may have to nail a piece of lumber to either one or both of the corners so that the cable has something to hold to. Pull the building into plumb, and then keep the tension on for a couple of days while the structure slowly settles into position. You might have to make adjustments during that period, according to my PM colleague Mike Allen, who worked on several of these straightening jobs in his early days in rural Michigan.

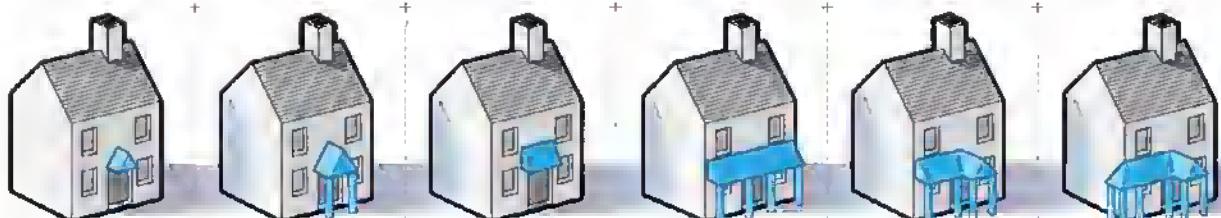
Finally, complete the job by installing diagonal bracing on the wall that was pulled into plumb, and the wall parallel to it. While you're at it, install diagonal bracing on the walls perpendicular to it. It's only another couple of pieces of lumber and a few nails. I'd use 2 x 4 or 2 x 6 lumber fastened with 12d common nails. Drive a pair of nails into each stud.

Off the Beaten Track

Our house has closet doors that slide past each other (not into the wall). We took them down to paint them and have had a hard time getting

■ DIY DESIGN

The Better Entry



Small Gable

This is the most typical entry covering. It's simple to build and works well for most house styles.

Large Gable

An expanded version of the gable entry is more complex to build in that it requires a pair of posts. A large gable, of course, provides more weather protection than a small one.

Shed

The shed-roofed entry lends a rural quality to the front entrance. Note that it needs a gutter across its front edge. Otherwise the drip from the roof edge will not only be a nuisance, it can erode landscaping or a masonry stoop.

Large Shed

A large shed-roofed front porch provides maximum protection from the weather and is a neighborly place to visit. It can also act as a gigantic awning, shielding front rooms from excessive sunlight.

Small L

If shading the front of the house will make it too dark, an architecturally interesting L-shaped entry may be the answer. Note that it combines peaked and shed roofs.

Large L

A large L-shaped porch and entry is architecturally rich but is more difficult to build. Note also that it can wrap around the sides. Here, it ends with a hip roof that juts out beyond the corner.

them back in place. They either don't hang properly or they pop off the track or scrape as they roll along. What are we doing wrong?

Unless the bypass closet doors are equipped with unusually good hardware, their rollers, tracks and guides will probably need to be replaced after 10 years or so of service. That can become apparent after they're taken down. While they worked moderately well before, they may barely work after they are reinstalled. If you've made several futile attempts at installing the doors, it may be time for a hardware overhaul. But there are a few things you can check first.

Stand each door upright so that it is parallel to you, then tilt the top slightly, and lift it so both rollers catch the track simultaneously. Gently let the door hang under its own weight. The door should rest plumb, and its top edge should be parallel to the track. If not, adjust the rollers so it hangs properly. Next, slide it back and forth. If the door comes off the track, the track's lip might be bent down. Bend it back up with a pair of pliers. Also, check that the track is firmly fastened to the closet opening. If not, tighten the screws driven through the track.

Finally, check the guide at the base of the door; it needs to be positioned properly. It has to be high enough so that it meets both doors and keeps them separate so they don't rub on each other. It can't be too high, though. If it is, the bottom of the doors will rub on it. The guide has to be positioned on the floor front to back so that it allows the doors to hang plumb. Adjust the bottom guide's position or replace it as necessary.

Hot Water Help

I want to set my electric water heater to save energy while producing as much warm water as possible. I'm confused, though, because it

THE DIY LIFE

The One That Nearly Got Away

There's a point at which you rely on a tool and use it so often that it becomes an extension of your hand. You can't picture yourself without it.

I have a ratcheting screwdriver that I use on nearly every job. Its unique gear case enables it to spin the bit either four times for every turn of the handle or at a one-to-one ratio. It works so well it can compete with battery-powered screwdrivers on some jobs, even boring small holes with a hex-shank drill bit.

Then, one day last summer, it slipped from my sweaty hand, bounced off the ladder I was standing on, and hit the concrete floor with a crack that

sounded like a rifle shot—at least to my ears. The tool survived with a small chip in the handle, but its trip to the floor made me consider my repair life in its absence. Even the best tool is one fall from oblivion or one turn shy of wearing out.

For weeks, I searched fruitlessly for a backup, then found it by accident when searching Google on an unrelated matter. I contacted the manufacturer (klenkttools.com) and learned that it's called Select-A-Bit DAB6450. You probably won't find it at your local hardware store, but it's available on the Web (www.innovativetools.net, for example). Moral? When a tool becomes indispensable, get a second one while you can. —R.B.

Years of use have shown the Select-A-Bit to be that rare breed: indispensable.



has two heating elements with a thermostat for each. Can I set one lower to save energy, or do I set them both the same?

Set both thermostats to 120 F. In fact, if the appliance is reasonably new, this is the temperature that it was set at by the factory. It produces sufficiently warm water for showering and dish-

washing while not producing a scald hazard. It also conserves energy. If you want to save even more energy, insulate the appliance, and install a water-heater timer so that it's producing hot water only when it's needed.

The heating elements come on sequentially. The bottom element heats water as it enters the tank, while the top element heats water as it exits. Usually the bottom element wears out first because it's activated more than the top element. Adjusting the thermostats to different temperatures will only interfere with the appliance's proper operation without providing any additional energy savings. —PM

 **ON THE WEB** > Check out Joseph Truini's five expert tips for easy weekend home improvements every Friday at popularmechanics.com/diyguy.

GOT A HOME MAINTENANCE OR REPAIR PROBLEM? Ask Roy about it. Send your questions to pmhomeclinic@hearst.com or to Homeowners Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we cannot answer questions individually, problems of general interest will be discussed in the column.

Painting Support

Magnetic Paintbrush Holder

Designed to clip to the rim of any size of can, this ABS paintbrush holder has integral magnets to securely hold a brush ferrule, allowing liquids to flow from the bristles back into the can. Includes a metal tab for opening cans.

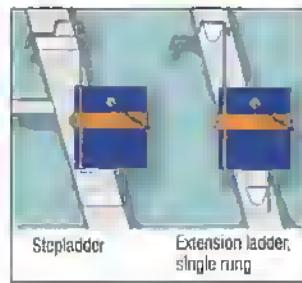
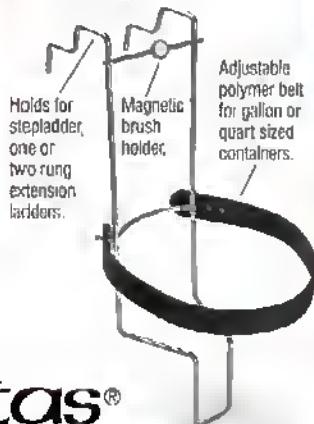
67K74.02 \$3.50



Michelangelo Paint Can Holder

Made from galvanized steel rod, this paint can holder fits all current North American stepladders 6' or taller, as well as all D-rung ladders. The mono polymer belt can accommodate quart or gallon cans. An integral magnet keeps a brush over the open can so you always have a hand free to grip the ladder. Patent pending.

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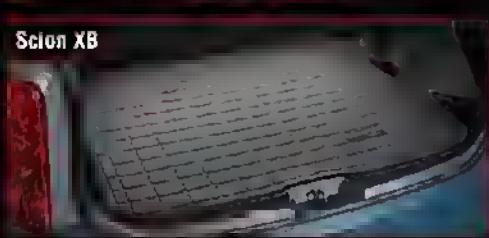
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Problems Starting Up?

DON'T GO OUT AND BUY A NEW BATTERY JUST BECAUSE YOUR CAR WON'T START.

Twist the key. Your car cranks for a second or two, springs to life, and then quickly settles down into a fast idle while it warms up. At least that's how it's supposed to work. This morning, no dice. It's dead, and there's no obvious reason why.

Here's how to figure out why your car won't run. The best approach to finding a solution is to remain methodical. This is classic systems analysis. Just follow the decision tree on the next page, and you'll find and cure the problem. Our decision tree is

STARTING ISSUES + FOGGED-UP WINDOWS + BACK-PROBING

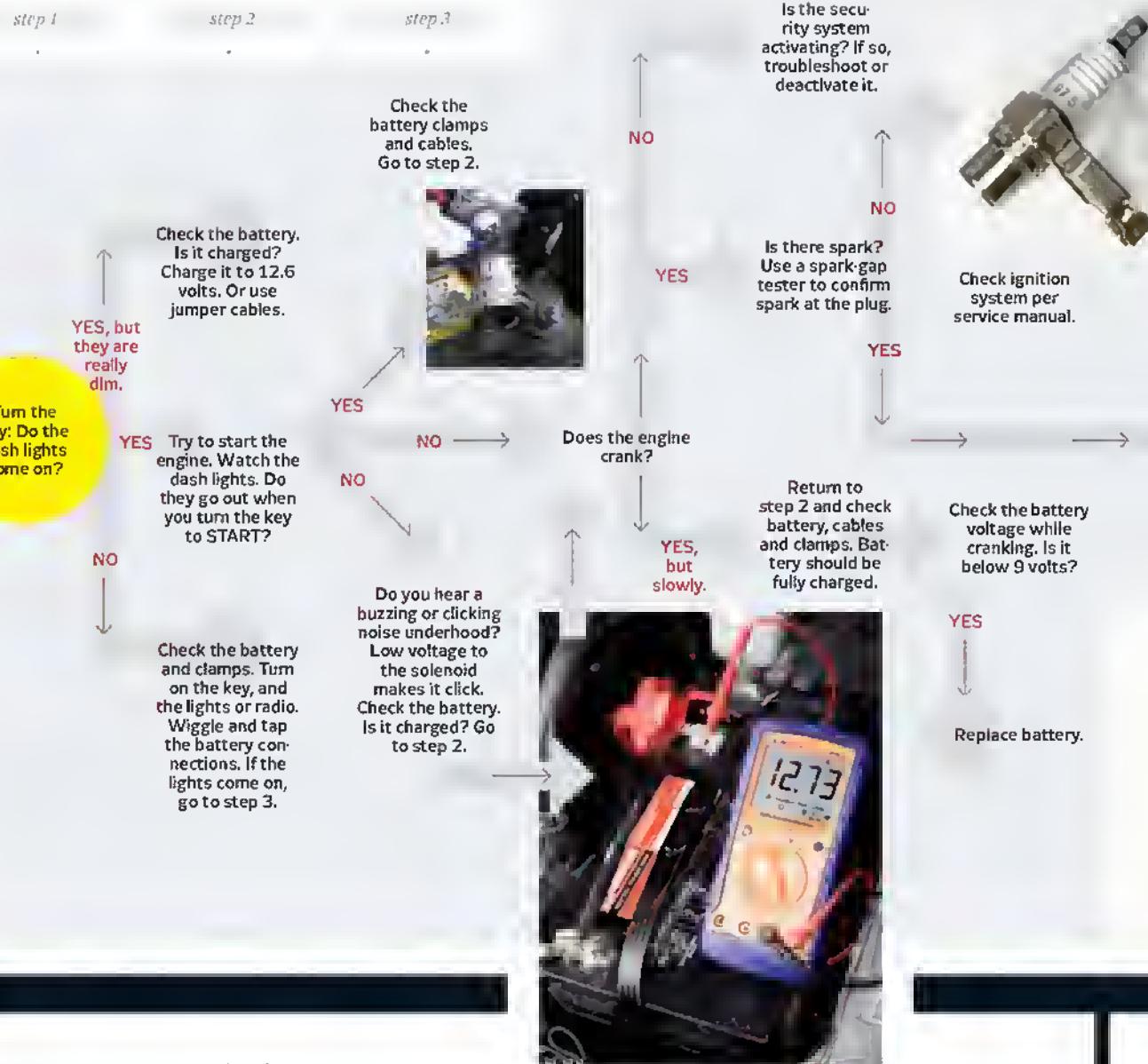
DIY AUTO

SATURDAY MECHANIC

DEGREE OF DIFFICULTY // EASY

generic, but it should resolve the majority of failure-to-start scenarios. The only real diagnostic tool you'll require is a decent multimeter. A fuel-pressure gauge and a no-id light, for testing fuel injectors, might be handy once you've ruled out the starter





motor and battery. You might also need a battery charger to bring the battery to a full state of charge, even if the engine is cranking, because you'll need a fully charged battery to do some of these diagnostics.

One point: If the battery is dead because you left the lights on, or you cranked AC/DC all night long, be sure to actually charge the battery. Don't just jumpstart your vehicle and make the poor alternator do all that charging at the same time that it's trying to supply the current to other systems. I know, I know, that may not be realistic when some kindly stranger is giving

you a jump in the parking lot at midnight in a blowing snowstorm. Let's try the first few stages of the flowchart, then you're on your own.

Getting Started

So you turn the key and nothing happens. Nada. No lights on the dash, no noise underhood, just the sound of your own muttered cursing from the driver's seat. You've got an electrical issue, and odds are it's an open circuit at the battery posts or cables. Unless

your vehicle has been in storage for years, there should be at least a little juice left in the battery, enough to dimly illuminate the instrument-panel lights. Your first step is to check the battery posts and cables. I'd bet a good whack with your shoe might re-establish the connection and put you on the road. Tip: Leave the key on and the radio up loud. If you're poking around underhood and it starts rockin', the problem is the last wire you touched. Or, another branch of the

step 7

step 8

step 9

step 10

step 11

step 12

Check fuel pump fuse, relay and wiring. Unfortunately, the fuel pump is inside the tank on most vehicles.

Listen for fuel pump. Does the fuel pump run for a few seconds after the key is turned on?

YES



Are the spark plugs wet with fuel? Pull one or two and inspect the electrodes.

YES



Dry out or replace the plugs.

Depress Schrader valve in fuel rail. Is there pressure? If possible, check fuel pressure with a gauge.

YES

Pinch off return line to tank. Is there pressure now?

NO

Check for a crimped or blocked fuel line. If it's fine, replace the fuel pump.

YES

NO

Check injector with no-id light or voltmeter. Is the injector firing?

NO

Replace fuel pressure regulator.

Get out the scan tool and factory service manual.



Get out the scan tool and factory service manual.



Check engine-computer-power fuse. Is the fuse blown?

YES

Replace fuse.

decision tree: The dash lights come on but go off when you try to start the engine. Could be either a discharged battery or corroded cables or clamps. So, time for step 3: Clean up the cables. Don't crank the engine for more than 15 seconds without a 60-second pause or you may overheat the starter motor. Let me say this again—follow the decision tree. There's one thing I learned working on cars many years ago. It's not uncommon to see multiple problems with intersecting symptoms. And if you try diagnosing that problem intuitively, you'll quickly make yourself crazy. Try solving

problems from the top down, and you'll find each one at a time. That's the way mechanics are taught, and that's the way that the car manufacturers expect a repair to proceed if they're going to pay for it under warranty.

Flooded

If you've discovered that you have wet spark plugs (rare on fuel-injected engines), you may not need to remove them to dry them out. Injected engines almost always have a Clear Flood mode: Depress the throttle to the floor, and then crank the engine. As long as you hold the pedal at full throt-

tle, the computer won't inject any fuel, and a few seconds of pumping air through the engine, without fuel, will dry off the plugs.

Following this chart should get 95 percent of all cars started. If you've worked your way to the right side of the chart, and the car still hasn't started, your last recourse might be to haul out the factory service manual, some tools and a scan tool to dig deeper into your car's black box. Different fuel-injection architectures call for different diagnostics; the factory manual will have those specific to your car.

Car Clinic

by Mike Allen

Probing Possibilities

Q My next-door neighbor used to be a mechanic. He was helping me investigate a short underhood, and warned me to always check the connections from the back of the socket, instead of the front—but he didn't know why. So ... why?

A This technique is called back-probing. It just means you insert the probe of the multimeter in the back side of the socket to make the connection, instead of the front. This is to prevent damaging the female socket with the probe, which is probably bigger than the accompanying male part of the socket. Modern automotive connectors, particularly the low-voltage types used for sensor and computer connections, are not designed to carry much current, often millamps or less. Consequently, they are small and fragile.

Back-probing is also a good way to access a circuit without disconnecting the connector, which is a good idea when chasing a voltage drop. However, a lot of connectors are sealed with gaskets or O-rings to the rear, making insertion of that probe difficult. Then what? I grab a mating connector pin out of the wiring repair box and insert it in the connector, and I can just use an alligator clip to secure it. Sometimes you can sneak a dressmaker's pin into the back without damaging the seals.

Quick Change

I bought a 2009 Ford Escape Hybrid in September. It just turned 1000 miles on the odometer. I would like to

Q + A

Poking blg voltmeter probes into the mating parts of an electrical connector may damage the spring-loaded contacts. Instead, back-probe.



change over to synthetic oil.

At what mileage would you recommend I make the change?

Read the owner's manual. Your Escape is already factory-filled with a synthetic; to wit: Motorcraft SAE 5W-20 Premium Synthetic Blend. So you can change anytime, although Ford's service manual says you can use a mineral oil if you choose. Many vehicles on the market today are filled at the factory with synthetics. I've never subscribed to the theory that you should use mineral oil for 10,000 or 20,000 miles to get the engine broken in before changing over.

Blown Filters

I work in a repair shop. A week ago, we replaced an oil filter on a Toyota Camry. This week, the owner came back to our shop and said that the oil filter exploded. What happened? Was the filter defective?

Defrosted

Why do my windows fog over and ice up so badly overnight? Some mornings I spend more time defrosting the windows than I do driving.

Start by keeping all the windows cleaner, so the moisture won't be attracted to the glass. I use a commercial antifog compound on the inside. It really does help. But make sure to keep the inside of the vehicle as dry as possible. If the car has carpeted floor mats, periodically bring them inside overnight to dry them out. I like to run the HVAC in recirc mode for the first few miles to hurry the heat along, but fresh air from outside the car—even on rainy days—is still drier than the air inside. Here's a secret: When you park



the car, turn the HVAC back to recirculate before you turn off the key. This will shut the air-blend door that opens the HVAC plenum to the outside, preventing moisture from entering overnight through the cowl.

I've blown up the odd filter or two, and it's usually because I did something I shouldn't have. One blown filter was caused by using too many revs on a cold racing engine filled with 40-weight straight-grade oil before it had sufficient time to warm up. That's tough to do on a street car filled with multigrade oil unless you're abusing your ride. Does this owner like to warm up the car at full throttle in the morning?

Another filter failure was from a stuck pressure-relief valve. A piece of gasket managed to jam the oil-pressure-relief piston, causing pressure to peg the oil-pressure gauge at any speed above idle. It popped before I noticed it, my attentions being diverted as the green flag fell at the start of a race. After I was yelled at by the chief steward for oiling down the front straight, we found the problem—once we replaced the filter, refilled the engine and started it up again. Fortunately, we could access the plunger without removing the engine from the car, so I made the afternoon race.

And sometimes, you just get a filter with a bad crimp, which is the most likely explanation. Nonetheless, I'd temporarily install a mechanical oil-pressure gauge in parallel with the idiot light in that Camry, and verify that the oil pressure is correct before I just screwed on a new filter and sent it on its way.

Lost Connection

I plan to disconnect the battery in my new Kia Sorento, which will be garaged in Maine while I am away for six months in Florida. Is there any harm in doing that?

No problem. In fact, it's a good idea. Cars have a residual power drain of a few milliamps after they're shut off, to maintain memory in the engine computer, the radio presets and the like. It's not much juice, but enough to drain the battery in a month or two. Disconnecting the ground strap will stop the loss.

Another issue is the battery's self-discharge, generally 1 to 2 percent a day, also sufficient to discharge it within a month or two. You can delay this by cleaning the battery's surface of any grease, dirt or corrosion. The surface contamination will attract moisture and become a conductive path for

a few milliamps to sneak directly from the positive terminal to the negative terminal, even if the battery is disconnected and removed from the car. Keep it someplace dry and above freezing. If the car is stored in an unheated garage, building or outdoors, it might be better to remove the battery and keep it inside a heated building. Unlike a fully charged battery, a discharged battery can freeze, which will permanently damage it. There is no credence that storing a battery on the ground will discharge it—but it does tend to be damp and cold under the porch or in unheated areas.

Six months is still too long to leave a battery to its own devices, no matter how well it's stored. Check the level of electrolyte when you disconnect or remove it, and add distilled water as appropriate. Pick up a small maintenance charger, one designed to be attached to a battery full-time. I use chargers from CTEK, BatteryMinder

and Battery Tender. An old-tech "trickle" charger will boil off too much water from the electrolyte. Regardless, check the electrolyte level before returning the battery to service. Final piece of advice: Disconnect the battery ground first, and reconnect it to the car last. And before disconnecting anything, make sure you know the security code for your stereo system.

Riding on Air

Is there any advantage to using nitrogen instead of compressed air in tires? Will I notice improved fuel economy or a smoother ride? Will my tires last longer?

Sort of. From the top: Air is 78 percent nitrogen, just under 21 percent oxygen, and the rest is water vapor, CO_2 and small concentrations of noble gases such as neon and argon. We can ignore the other gases.

There are several compelling reasons to use pure nitrogen in tires.

■ MIKE'S DRIVING TIPS

Car Control 101

DON'T FREEZE UP—KEEP DRIVING EVEN IF YOUR CAR IS A LITTLE OUT OF CONTROL.



It's winter, and I'm seeing a lot of bent rims and out-of-alignment cars. Why does soft snow cause bent parts? I'll tell you.

Yesterday I saw a driver overestimate the traction available

as he slowed for a corner. With the wheels cocked hard left and the brakes fully locked, he slid across the intersection into a curb. Scratch one lower control arm, ball joint, wheel bearing,

half-axle and rim. On a luxury car, that could be a thousand-dollar repair. Some advice, then: You've overstepped the laws of physics yet again, and you're going to eat a curb or a pothole. Minimize the damage: Don't hit anything with the wheels turned. Straighten out just before impact, then release the brake just before colliding—this allows the wheels to rotate, and you'll stand a better chance of rolling up on top of the curb instead of digging in and busting something. Or, worse yet, flipping over onto the roof. Ouch.

—M.A.

First is that nitrogen is less likely to migrate through tire rubber than is oxygen, which means that your tire pressures will remain more stable over the long term. Racers figured out pretty quickly that tires filled with nitrogen rather than air also exhibit less pressure change with temperature swings. That means more consistent inflation pressures during a race as the tires heat up. And when you're tweaking a race car's handling with half-psi changes, that's important.

Passenger cars can also benefit from the more stable pressures. But there's more: Humidity (water) is a Bad Thing to have inside a tire. Water, present as a vapor or even as a liquid in a tire, causes more of a pressure change with temperature swings than dry air does. It also promotes corrosion of the steel or aluminum rim.

If I ever need to top off a tire when

I'm out on the road, I'll always briefly depress the tire chuck's valve with my thumbnail and vent some air. If my thumb gets wet, there's water in the line. Some gas stations don't do a very good job of keeping the humidity out of their air system. I don't even like to use a water-based tire-mounting lubricant unless I can let the tire bake in the sun for a couple of hours before I air it up and seat the bead. I've dismounted tires (not mine) that had several quarts of water inside—probably from a compressed-air hose that collected water and was never purged properly.

How is water relevant to a nitrogen discussion? Any system that delivers pure nitrogen is also going to deliver dry nitrogen. Filling tires with nitrogen involves filling and purging several times in succession, serially diluting the concentration of oxygen in the tire. This will also remove any water.

It's certainly simple, although time-consuming, for a tire technician to fill and bleed tires. But most shops use a machine that not only generates almost pure nitrogen by straining the oxygen out of shop-compressed air, but will also automatically go through several purge cycles unattended. Some shops have been charging as much as \$30 per tire for this service. I think that's too much. If you're buying a new tire, it should be far less. Still, the nitrogen generator, filling system and technician's time aren't free—the dealer is entitled to some return for that.

So, to answer your specific questions: With nitrogen, your tire pressures will remain more constant, saving you a small amount in fuel and tire-maintenance costs. There will be less moisture inside your tires, meaning less corrosion on your wheels. You will *not* be able to feel any difference in the ride or handling or braking, unless your tire pressures were seriously out of spec and changing to nitrogen brought them back to the proper numbers.

Light the Night

The other night I was on a long drive when I noticed one vehicle with bluish headlights among the thousands passing in the other direction. This reminded me that some years ago these blue headlights began appearing frequently. Now, I rarely see them. What happened? (I never liked them anyway!) Those blue-colored headlights were probably HID (high-intensity discharge) headlamps on some high-end luxury car. These lamps use a spark discharge in a high-temperature quartz envelope instead of a tungsten filament. They aren't really blue—they are actually very close to daylight in color. We just see them as blue because the old-technology halogen bulbs we usually use are nearly orange by comparison. The HID lamps deliver a sharper cutoff in

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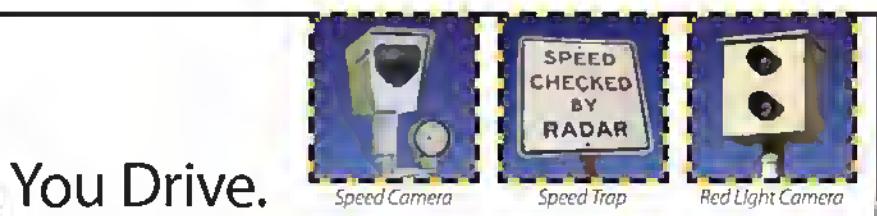
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their pattern because the source of light inside them more closely approximates a point source. They also use far less current, typically 4 amps, as opposed to the 10 or so that halogens use. I can't say why you're not seeing more of them; they've increased in popularity and are available on less expensive cars all the time.

As to your dislike for them, perhaps you're confusing them with a less-expensive alternative: conventional tungsten-halogen bulbs that are engineered with bluer light. That's largely a fad to imitate HID lamps. I see some of them actually marketed as "HID" bulbs, which they are not. So much for truth in labeling. If it plugs directly into a socket and replaces a standard quartz-iodine bulb, it's not HID. An HID lamp requires a high-voltage ballast to start the internal arc and maintain it at the appropriate current, and it can't be properly retrofitted in a conventional socket.

Some of these after-market lamps, whether labeled HID or not, are not well made, and tend to send stray light into oncoming traffic, blinding drivers. So it's no wonder you have acquired a dislike for these. If you ever drive with true HID lamps, you'll understand why people pay thousands extra for them. **PM**

GOT A CAR PROBLEM? Ask Mike about it. Send your questions to pmoutoclinic@hearst.com or to Car Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we cannot answer questions individually, problems of general interest will be discussed in the column.



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DIY TECH



Home automation allows you to preprogram and save multiple settings for various systems around your house (sprinklers, climate control, outdoor lighting and others), then log in and control them through a PC or cellphone.

Home Control

BY LINKING A HOME AUTOMATION SYSTEM TO A WI-FI NETWORK, WE TURNED A CELLPHONE INTO A WHOLE-HOUSE REMOTE. BY GLENN DERENE

Home automation exists in the curious realm where screwdrivers and drywall meet PCs and routers. The category is still evolving—there are multiple, incompatible standards—and getting this stuff to work requires knowledge of both household electrical wiring and computer networking, but once everything is hooked up correctly, it can change the way you interact with your home.

Last month, I wrote about installing Insteon networked lighting in my home, which allowed me to link up switches and outlets throughout my house regardless of which branch circuit they were on.



The Insteon system works by sending data signals over radio frequency (RF) waves and your home's power lines. As each device receives a signal, it rebroadcasts it, creating a mesh network that bounces commands instantly from one end of the house to the other. It's an effective system for connecting lighting switches and loads without extra wiring, but it also forms the basis for a more sophisticated home automation network.

Meshed Networks

Home automation is a broad and even somewhat vague concept. And plenty of companies sell systems that do everything from basic lighting control to full integration of home entertainment systems, motorized window blinds, climate control and home security. Many of these "whole home automation" systems from companies such as HAI and Crestron are geared toward the installer market and can cost many thousands of dollars. Other systems, such as Smart-Labs' Insteon and the competing Z-Wave system, tend to be more flexible and aimed at DIYers.

Obviously, since I had already outfitted my house with Insteon's lighting controls, it made sense to build upon that system. The first step was to integrate my networked lighting into my home's data network. Insteon has a variety of different network interfaces, but I went with the \$120 SmartLinc controller. The SmartLinc serves up its own Web page on your home network, allowing you to control your system from a browser window on any computer in the house, or via cellphones

To integrate climate control with a home automation network, upgrade to a thermostat (left) that can interface with a compatible RF transceiver.

Insteon's SmartLinc bridges the home automation network with your local area network's Wi-Fi router (below, left) via an Ethernet cable.

The SmartLinc serves up a Web page interface (below, right) for programming and controlling all of your home-control devices from a PC or cellphone.



with Wi-Fi capability.

Installation is simple: Just plug the SmartLinc into a wall outlet, then connect it to your Wi-Fi router via an Ethernet cable. The Web interface allows you to set up virtual On/Off switches for any Insteon controller.

More advanced users can even set up control of their home systems from outside the home network. By enabling "port forwarding" on your household router, you can access and control your systems from anywhere with Internet service.

Remote Climate Control

Once the Insteon system was linked into my router, I was able to expand automation to other home systems such as climate control. If my wife and I decided to go out for dinner directly from work, I could log into the Smart-

Linc from my iPhone and change my thermostat's program—no need to heat the house when no one's there.

Hooking up that system was a bit more complicated and expensive than I anticipated. To use Insteon's RF-based thermostat adapter (\$100), I needed to replace my existing Honeywell digital thermostat with a compatible Venstar T1800 thermostat (\$95). I also needed a two-pack of plug-in RF Access Points (\$70) to link the thermostat with the SmartLinc. As I discovered during my previous lighting installation, the toughest part of swapping in Insteon equipment is deciphering the wiring of your existing system.



It took me 2 hours of experimentation and three calls to an Insteon rep to get my Venstar thermostat installed correctly. But after that, hooking it into the SmartLinc's Web interface took only a minute or so—such is the gulf between my technological and household electrical faculties.

As I complete each new home automation project, my ambitions for the system grow. And there is a surprising array of Insteon equipment available to link into your network, from sprinkler controls to outdoor lighting to automatic pet-feeding systems. Sure, this sort of remote household micro-management can get ridiculous, but ask yourself, which is worse karmically: Interrupting dinner with the family to check e-mail on a BlackBerry, or pausing for a moment at the office to water your lawn with your iPhone? **PM**

Digital Clinic

by Seth Porges

Q + A



The quickest way to make a gadget run longer: Dim the screen, turn off the GPS and cut wireless connections (such as Wi-Fi, Bluetooth and 3G) when they aren't in use.

Conservation of Charge

Q The lithium-ion batteries in my electronics never seem to last long enough. How can I make them go longer between charges?

A These days, we ask a lot of our gadgets. They, in turn, ask a lot of their batteries. And while the lithium-ion batteries that power most of today's mobile devices are an improvement on the ones electronics used to rely on (they last longer and don't have a "battery memory" effect to worry about), having a laptop expire midflight is still frustrating. Short of any chemistry breakthroughs, our batteries won't be getting much better anytime soon. That means it's up to us to stretch their abilities as far as possible.

For just about any lithium-ion-powered gadget, there are a few basic

rules that should help with battery life. First, try to avoid extreme hot or cold temperatures—these conditions can limit the charge. You'll also want to go through at least one charge cycle a month. A battery won't lose its charge as quickly if you keep its electrons moving. If you know it's going to be a long time before you use a gadget again, run its battery down to a bit under half of the maximum charge and leave it in the fridge (but never the freezer). And for many electronics, downloading the latest firmware from the manufacturer's Web site can provide better battery management.

Phones

Modern mobile phones are communication addicts. Even when they aren't making calls, they are constantly pinging cell towers, searching for networks and grabbing e-mail from the data cloud. All these connections use a lot of power. So turn off your phone's Bluetooth when you aren't using a wireless headset or transferring data, turn off its 3G connection and Wi-Fi when you aren't surfing the Web or using data-intense applications, and turn off the GPS receiver when you aren't trying to pinpoint your location. And while smart phones such as the iPhone can continuously check for and download new e-mails, each of these check-ins uses power. Turning off this "push e-mail" and pulling your messages manually (and less frequently) will stretch your battery life.

Other preventable phone battery wasters: the speakerphone, the "vibrate" function and anything that uses the phone's processor or screen, such as pictures, music, movies and games. Keeping the key lock on can prevent accidental in-pocket button pushes from wastefully turning on the screen's backlight.

MP3 Players

If battery life is important, opt for an MP3 player that stores its data on flash memory. Hard-drive-based players usually hold more songs, but they also have more moving parts, which translates into shorter battery life.

You'll also want to adjust a few key settings. First, set the backlight timer, which controls how long a screen's backlight stays on after a button has been pressed, to the minimum time available. Then make sure the sound equalizer (called simply "EQ" on iPods) is turned off—that added bass boost doesn't come for free. However, if you're using an iPod and made changes to a song's equalizer preset within iTunes, this won't help. In this case, switch the EQ setting to "Flat."

And as tempting as it is to song-surf, it's more efficient to simply let a playlist or shuffle run without skipping. Not only does jumping tracks trigger the screen's backlight, but it also calls

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the player's processor (and hard drive, if it has one) into service. And, with some MP3 players, sticking to shorter songs can save power. The iPod, in particular, uses a memory cache to store upcoming tracks. This cache is designed to work most efficiently with music files that are smaller than 9 MB.

One last point: Most MP3 players face substantial power penalties when they play tracks with antipiracy digital rights management built in. This is because it takes processing power for the players to decrypt the files. So stick to simple MP3s when possible.



Cameras

Auto-flash and autofocus functions allow anybody to point and shoot with just about any camera. However, these crutches are battery-busters. Cutting back on your use of a camera's flash and autofocus won't just allow you to take more photos between charges, it will also make your shots more interesting. So try manually adjusting the focus (assuming your camera allows you to). And instead of using a flash, increase the camera's light sensitivity by raising the ISO setting, or adjust the exposure manually, if you can.

Still, a camera's single biggest battery-burner is its LCD screen. Framing your shots with the optical viewfinder (assuming your camera has one) can yield massive power savings. Likewise, fight the temptation to repeatedly review your shots on the screen.



Laptops

First stop: Your laptop's pre-programmed power-saving settings. These save juice by trimming down on a computer's internal activity, typically by minimizing the unnecessary use of its processor, screen and hard drive. To find these settings in Windows Vista, go to your computer's Control Panel and click Power Options, then Power Saver. For Macs, click into System Preferences and then Energy Saver. You can even create a custom setting that will save more energy by cutting power to these components after they've been idle for

as little as 1 minute.

The optical drive is one of the biggest bandits. Instead of watching movies off of DVDs, watch them off your hard drive. Another culprit: external components, particularly powered USB gadgets that piggyback off your laptop's battery. If battery life is a concern, stick to a laptop's own keyboard and trackpad.

As with other gadgets, dimming a laptop's screen will save power. But you can save even more by turning the backlight off completely when it's not needed. Turn the brightness down until the backlight is completely off while you wait for idle tasks such as downloads and file conversions to complete.

You'll also want to turn off scheduled tasks and close applications that aren't in use—particularly ones that launch automatically at startup. And, as with anything with a wireless connection, kill the Wi-Fi and Bluetooth when you aren't using them.

Oddly, a battery doesn't need to be completely dead for a laptop to shut down—the computer just needs to think it's dead. Recalibrate the circuits

tech term

RANSOMWARE: A Trojan or virus that holds your data hostage.

→ This computer-security threat infects your PC, then encrypts your data so that you can't access it. "In your documents directory, you'll find that every file is encrypted except a single text file," says Kevin Haley, director of security response at Symantec. "And that's the ransom note." The message usually demands that you send money to get a key to decrypt your files. Unfortunately, if you've stumbled upon old ransomware, its creators may have packed up shop long ago, leaving you with no way to get the decryption key.

that keep tabs on how much battery life is left by running the battery down completely and charging it back up. Do this every 30 or so charge cycles.

Mislabeled MP3s

My MP3 collection is full of mislabeled tracks. Is there any easy way of fixing this?

MP3 players and music-playing programs organize your music library using information such as a song's title, artist and track number. This info is contained in what's called an ID3 tag. These tags are often woefully incomplete, especially if you didn't fill them in when you ripped a CD (which can result in a library full of songs called "Track 1"), or if your music was downloaded from less-than-reliable sources. This can cause trouble when, for example, iTunes mistakenly believes Kanye West is an album by the band Late Registration, making it difficult to find "Gold Digger" on your iPod.

Manually filling in all this information is easy enough (you can change it by clicking on a song's title or artist in iTunes and typing in a new one), but it can be a herculean task for those with large libraries. Fortunately, a number of free programs, such as Magic MP3 Tagger (magic-tagger.com), do it automatically. These programs compare a poorly labeled song against a database of tracks and fill in missing info. These applications also detect duplicate files.

Silent Startup

The startup sound on my MacBook is loud. Is there any way to mute it?

Windows users can easily silence startup sounds via the Control Panel without affecting output volume levels. But Mac users don't have this option. Apple's official position is that users should mute the output volume in System Preferences before shutting down. And while this solution will avoid waking the baby, we've found that simply plugging a pair of headphones into our MacBook is a more convenient way to eliminate that disruptive startup chime. **PM**

HAVE A TECHNOLOGY PROBLEM? Ask Seth about it. Send your questions to popularmechanics@hearst.com or to Digital Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we cannot answer every question individually, problems of general interest will be discussed in the column.

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is only temporary, you can make it permanent by changing the hydrogen bond angle! However, it's a proprietary matter to keep the angle at 114° and produce the "light" water mentioned in the *Washington Post* article. It's like a balloon. With a wider bond angle, the molecules are larger and the water is 4% lighter/unit volume than ordinary water! There are only a few places in the world where this occurs naturally including Lourdes and Nordenau (both 4% lighter and tested 100's of times)! However, you have to constantly replace the water you are eliminating to produce these results! Scientists and M.D.'s acknowledge that this is the only machine in the world that can produce "light" water! Textbooks don't tell you how this is done or a patent (without proprietary details) wouldn't be allowed! As a result, although you might find it necessary at an obscure university (a person's picture speaks 1,000 words), a UCLA M.D. said: "How can anybody argue with something you can measure? We can measure blood flow to the extremities and nothing comes even close to your water!" His tests confirmed the 100's of tests done around the world and the news articles about "light" water. As a result, we stopped counting at over 100,000 users!

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5. Being highly impressed by the results and purchasing a ROM.
6. Becoming a ROM enthusiast and trying to persuade friends.
7. Being ignored and ridiculed by the friends who think you've lost your mind.
8. After a year of using the ROM your friends admiring your good shape.
9. You telling them (again) that you only exercise those 4 minutes per day.
10. Those friends reluctantly renting the ROM for a 30 day trial. Then the above cycle repeats from point 5 on down.

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